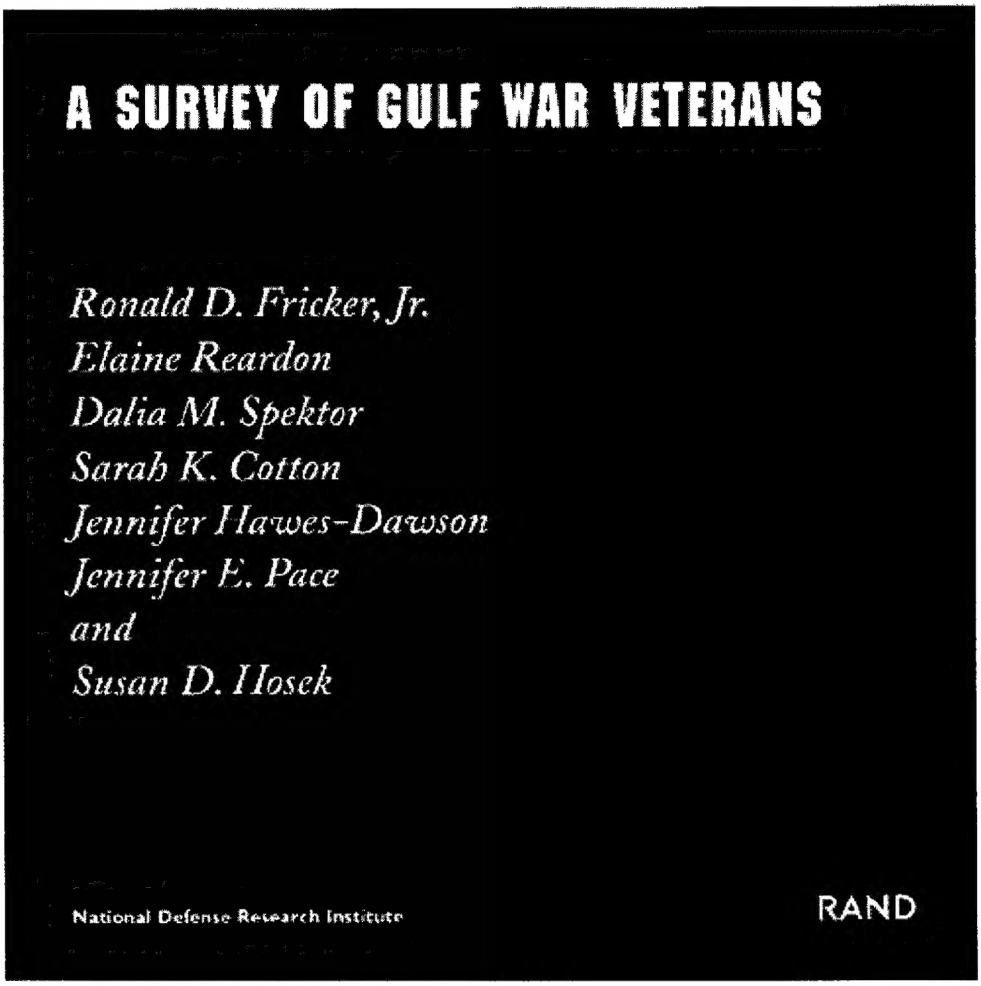
Pesticide Use During the Gulf War



Pesticide Use During the Gulf War: A Survey of Gulf War Veterans

Donald D. Fricker, Jr., Elaine Reardon, Dalia M. Spektor, Sarah K. Cotton, Jennifer Hawes-Dawson, Jennifer E. Pace, Susan D. Hosek

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Preface

Some veterans of Operation Desert Shield/Desert Storm (ODS/DS) have reported an array of health complaints, including fatigue, joint pain, skin rash, memory loss, and diarrhea. Many of these veterans attribute their poor health to deployment to the Persian Gulf. Whether these veterans are experiencing higher-than-expected rates of identifiable illnesses with known etiologies or other illnesses of unknown origins is the subject of a great deal of on-going research.

This study was commissioned by the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses to help quantify how pesticides were used during ODS/DS because overexposure to pesticides can cause symptoms similar to those reported by some Gulf War veterans. The goal of this survey is to quantify pesticide use by the average soldier during ODS/DS: Which pesticides were used, who used them, and in what quantities. Our results complement other data collection efforts by the Department of Defense, such as interviews with military preventive medicine personnel and entomologists.

Designed as one part of the larger research effort, this survey provides information only about pesticide use; it was *not* designed to investigate whether such use is related to health outcomes or symptoms.

Two other reports, to be published concurrently with this one, examine the literature on the known effects of pesticides on health and the possible effects of pesticides on troops in the Gulf War. One examines the latest scientific knowledge about the possible human health effects of pesticides (see Cecchine et al., forthcoming). The other, being prepared by the Office of the Special Assistant for Gulf War Illnesses (OSAGWI), investigates what happened in the Gulf and its likely effect on the service members who served there. They will provide additional information about pesticides that, in conjunction with the information in this report, may help address the broader question of health effects for veterans of ODS/DS.

The results in this report are a significant contribution to the broader question because little is known about the use (or misuse) of pesticides during the Gulf War. Before this survey, logistics information quantifying the amount of

military-issue pesticides ordered from the theater of operations and interviews with preventive medicine personnel provided the best available data on pesticides used in ODS/DS. However, that information failed to account for pesticides acquired outside of the military supply system and provided little information about how pesticides were used by the average soldier.

In an effort to gather additional information, this survey was designed to solicit detailed data both on pesticides personally used by individuals and pesticides used or observed in the field. The data consist of telephone interviews with 2,005 veterans who were randomly selected to be statistically representative of the entire Gulf War population on the ground in the Kuwaiti theater of operations. The complete survey instrument is available as a RAND report (Spektor, Reardon, and Cotton, forthcoming), and the data we collected[1] are available on the World Wide Web at http://www.rand.org/natsec/gulfwar.html.

The audiences for whom this report is intended include military and civilian officials responsible for doctrine and policy related to the employment of pesticides in the U.S. military, the protection of the

health of U.S. military personnel, and the conduct of supporting medical and scientific research. This report may also be of interest to Gulf War veterans and veterans' groups concerned with the issues surrounding Gulf War illnesses, as well as to the American public at large concerned with policies related to the protection and treatment of U.S. military personnel.

This research is sponsored by the Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses and was carried out jointly by RAND Health's Center for Military Health Policy Research and the Forces and Resources Policy Center of the National Defense Research Institute (NDRI). NDRI is a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the unified commands, and the defense agencies.

This report is one of several by RAND commissioned by the Special Assistant for Gulf War Illnesses. Other reports address the military use of certain drugs not yet approved by the Food and Drug Administration and review the scientific literature on the health effects of chemical and biological agents, pyridostigmine bromide, oil fire pollution, depleted uranium, pesticides, infectious diseases, immunizations, and stress.

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[1]Appropriately de-identified to protect survey participants' anonymity.

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Summary

Veterans of Operation Desert Shield/Desert Storm (ODS/DS) have reported an array of health complaints since the war. These complaints are often attributed to the veterans' deployment to the Persian Gulf, and the reported ailments have been popularly labeled *Gulf War illness*. Whether veterans are experiencing higher-than-expected rates of either known or unknown illnesses has not yet been determined. However, by 1997 the Veterans Administration (VA) had recorded approximately 15,000 veterans with undiagnosed symptoms, commonly including fatigue, muscle and joint pains, headaches, memory loss, skin rash, diarrhea, and sleep disturbances.[1]

Symptoms similar to some of those reported by Gulf War veterans may result from overexposure to various pesticides, but little is known about the use (or misuse) of pesticides during ODS/DS, particularly pesticide use by the average service member. In an effort to gather additional information, RAND was commissioned by the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses to survey veterans about the pesticides they personally used and other pesticides they used or observed being used in the field. The purpose of the survey was to augment available information about the extent of pesticide use by the troops, the level of multiple pesticide use, and the duration and frequency of use.

WHY SURVEY?

To date, a conclusive cause of illnesses among Gulf War veterans has not been found. We do know, however, that overexposure to various pesticides can cause symptoms similar to some reported by Gulf War veterans. Overexposure to pesticides, the use of pyridostigmine bromide (PB) pills (given to personnel in ODS/DS as a pretreatment to protect primarily against the nerve agent soman), and perhaps a combination of both pesticides and PB pills are among the possibilities still under investigation.

Before this survey the only available data on pesticides used in ODS/DS were (1) individual interviews conducted by the Office of the Special Assistant for Gulf War Illnesses (OSAGWI) with preventive medicine personnel, (2) logistics information quantifying the amount of military-issue pesticides ordered from the theater of operations, and (3) limited information from various epidemiological studies that have been conducted. However, the logistics information does not account for pesticides acquired outside the military supply system, and it does not provide any information about how the pesticides were used. The preventive medicine interviews, on the other hand, provide some information on field-use pesticides, but they provide little information about how personal pesticides were used by the average service member, and the results are not easily generalized to the entire Gulf War population.

Our survey results complement the other data collection efforts by the Department of Defense, such as interviews with military preventive medicine personnel and entomologists. Designed as one part of a larger research effort, this

survey provides information only about pesticide use; it was *not* designed to investigate whether such use is related to health outcomes or symptoms.

WHO WAS SURVEYED AND WHAT INFORMATION WAS COLLECTED?

We conducted a telephone survey of 2,005 veterans from May to October 1999. They were randomly selected to be statistically representative of the Gulf War population. We drew the survey participants from Army, Air Force, Marine Corps, and Navy personnel who served *on the ground*[2] in the Kuwaiti theater of operations (KTO) between August 1, 1990, and July 31, 1991. Our population consisted of

- All Army and Marine Corps personnel located in Saudi Arabia, Kuwait, and Bahrain;
- All Air Force personnel located in Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, and Oman; and
- Navy personnel in units that were identified as being ashore in Saudi Arabia, Kuwait, and Bahrain.[3]

The Department of Defense has estimated that 697,000 personnel participated in ODS/DS. After removing those who were not eligible for the survey, we estimate that 469,047 personnel were actually on the ground in-theater during the one-year period of interest.

We designed the survey to elicit information about veterans' personal use of pesticides and those they observed others use. We solicited specific information about the identification and frequency of use of many possible pesticides, including common personal-use pesticides, unusual personal-use pesticides such as pet flea collars, and various common and rare field-use pesticides (such as aerial spraying). The pesticide information was elicited in the context of the veterans' living, working, and eating conditions for one randomly chosen month that each respondent was in theater.

Considering that this survey was fielded years after the end of the Gulf War, there was little expectation that the respondents would be able to recall the names of all the products used, especially those used in the field. In fact, Gambel et al. (1998) indicate that Army soldiers deployed in Kuwait, Haiti, and Bosnia had difficulty identifying military-issue personal-use pesticides during their deployment. Therefore, we employed a strategy in which the respondents focused on the forms of the pesticides. The forms included were lotions, sprays, powders, liquids, flea collars, small solids (specifically, pellets, crystals, and granules), and "other." For each form that a respondent indicated using, the pesticide name was first solicited--either its active ingredient or its trade name. If the name could not be recalled, a description was then solicited in terms of its color and smell.

We also randomly selected a subset of respondents who agreed to be reinterviewed with selected questions from the original survey to assess the reliability of their answers. We administered the second "recall bias" survey after about six weeks, during which time respondents were generally expected to have forgotten how they answered the first survey. In this way, we were able to examine if and how their answers changed over time.

WHAT DID WE FIND OUT?

We found that the majority of respondents were not able to recall specific pesticide details (such as name, color, or smell). As we expected, this difficulty was exacerbated for field-use pesticides that the respondents may have observed but usually did not apply themselves. The result is that we generally could not identify the active ingredients in pesticides from the survey responses. Thus, most of our tabulations and analyses were limited to identifying the form of the pesticide (such as spray,

liquid, etc.), which respondents were able to recall relatively well.

We also found that the number of types of pesticides used or observed increased 13 percent from the initial survey to the recall bias survey. This difference occurred primarily among respondents who had given less thought to their Gulf War experiences in the intervening years. We also found that reports on frequency of use increased slightly in the recall bias survey. A "worst case" interpretation of this result is that the incidence of pesticide reporting, as we describe below, may slightly underestimate the actual use during ODS/DS, although the mix of pesticides reported in the main survey does not appear to be misestimated.

We examined recall in other ways, such as by education, by self-reported current health, and by whether respondents had thought much about pests and pesticides in the Gulf before the interview. The health question was a simple self-assessment, rating health as excellent, very good, good, fair, or poor. It is interesting to note that we found no significant variation in reports of pesticide use by health status, and no evidence of a dose-response type of relationship. Of course, this could be due to a number of factors, including small sample sizes, differences between two variants of the question, and other methodological reasons.

Basic Tabulations of Use

Personal-Use Pesticides. Personal pesticides are those obtained and used by individual service members, primarily for their personal comfort, either on their bodies, on their uniforms, or in their personal living spaces. Table S.1 lists our estimates of the percentage of the population using each form of pesticide and the median frequency of use per month (among those who reported using the pesticide form). We estimate that more than one-third of the population did not use any personal pesticides. Sprays were the most frequently used form of pesticide, followed by lotions and liquids.

Table S.1
Use of Personal Pesticides by Form

Form	Percentage (No.) of Population Using Form	Median Frequency of Use per Month[a]
Spray	44 (207,414)	30
Lotion	26 (120,460)	20
Liquid	23 (105,425)	30
Powder	7 (33,790)	16
Flea collar	3 (13,291)	26
"Other"	2 (7,440)	12
None	38 (177,300)	--

[a]Among those who used the pesticide form.

Enough information was available on three personal-use pesticide active ingredients to allow us to impute the extent and frequency of their use. Table S.2 gives our imputed results, based on an assumption that the pesticides were appropriately used. ("Appropriately used" means that we assumed that sprays used on the body were DEET-based and not permethrin.) We found that one-half of the population used DEET, and those who used it did so with a median frequency of 30 times a month. Permethrin and sulfur were used less extensively and less frequently.[4]

Table S.2
Use of Personal Pesticides by Imputed Active Ingredient

Ingredient	Percentage (No.) of Population Using Ingredient	Median Frequency of Use per Month[a]
DEET	50 (235,962)	30
Permethrin	6 (30,032)	20
Sulfur	3 (15,437)	15

NOTE: Imputation assumed that pesticides were appropriately used, that is, that sprays used on the body were DEET.

[a]Among those who used the active ingredient.

Field-Use Pesticides. Field pesticides were generally those used in larger living, working, and exterior spaces. They may have been available to and applied by the respondent, and they may also have been pesticides that the respondent observed being applied. Table S.3 gives the basic results for field pesticides. Additional details about use of personal and field pesticides, including breakouts by service, can be found in Chapter Three.

Table S.3
Use of Field Pesticides by Form

Form	Percentage (No.) of Population Using Form	Median Frequency of Use per Month[a]
Aerosols	28 (133,329)	30
Other sprays	20 (92,083)	4
Powders	13 (62,150)	16
Pellets, crystals, or granules.	12 (54,548)	30
No-Pest strips	7 (30,530)	(b)
Liquids	4 (18,242)	21
"Other"	3 (12,872)	30
None	51 (239,214)	--

[a]Among those who used the pesticide form.

[b]These data recorded the number of No-Pest strips per 100 square feet. Please see Table 3.18 for details.

Multiple Use of Pesticides. Figure S.1 shows the distribution of the number of personal pesticide forms used in theater. The figure shows, as previously mentioned, that more than one-third of personnel did not use any personal pesticides. Slightly over half of the population used one or two forms, generally a spray or a spray with either a liquid or a lotion (see Table S.1). The figure shows that very few personnel used more than two personal pesticide forms in any month.

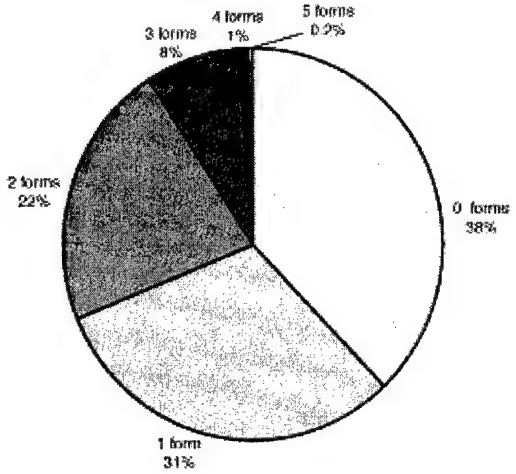

Figure S.1--Number of Personal Pesticide Forms Used

Variations in Use

We also evaluated differences across various subpopulations and found significant differences in living conditions and pesticide use. The most general differences were by service, where Army personnel used personal pesticides more generally and more frequently, followed by the Marine Corps/Navy. The Air Force used pesticides the least of all the services. This trend holds roughly for field-use pesticides as well, although the Air Force and Marine Corps/Navy reported higher use or observance of "other" sprays.

We found few differences by season when we compared responses for summer (April-October) and winter (November-March). In particular, we found that personal sprays and liquids were more likely to be used by more personnel in the summer, although there was no difference in the frequency of use. Those who wore flea collars, however, wore them less frequently in the summer. We found no other statistically different seasonal differences.

We found some differences in use of personal pesticides by rank. In particular, officers were less likely to use lotions and flea or tick collars, and they used powders less frequently. Senior enlisted personnel used both sprays and powders more frequently. And, although we found some differences in use of field pesticides by rank, we concluded that the differences probably came about because senior personnel were in a position to be more aware of the use of field pesticides, although some of the difference may also be due to differences in living conditions.

Finally, we also found some differences in pesticide use by living arrangements that are consistent with our expectations of how pesticides would be employed. For example, personnel who lived in buildings were less likely to use sprays and liquids, whereas those living in the desert and "other" places were more likely to use these pesticide forms.

Misuse of Pesticides

Given the nature of the survey data, it was difficult to evaluate whether pesticides were used properly because the data were primarily frequency of use by form. Without data on color and smell, it was often not possible to link any given form specifically to an active ingredient. Without the active

ingredient, it was not possible to classify misuse in terms of frequency of use. Furthermore, even when the respondent did name a pesticide, our conclusions were still inextricably confounded with recall bias and accuracy issues.

Cases of clear misuse of specific, identifiable pesticides (assuming that the respondents' answers were correct and accurate) included permethrin, d-phenothrin, lindane, and flea or tick collars. However, the number of individuals reporting use of the first three pesticides were very few. The one clear exception, both in terms of identifiability and prevalence of use, is flea or tick collars. We estimate that over 13,000 service members used flea or tick collars during their tours of duty, and there is little question that the respondents correctly identified and reported the pesticide product.[5] Also, we found evidence that No-Pest strips were sometimes hung in densities greater than recommended by the manufacturers, particularly in some eating areas and latrines.

Field-use pesticides were even more difficult for respondents to identify. We did not find any indications of widespread misuse of field pesticides by the general (untrained) population, and we interpret this lack of information to mean that these pesticides were not available to the general population.

It was similarly difficult to find conclusive evidence of overuse of multiple pesticides because calculating frequency of use by form unavoidably combines various active ingredients in unknown ways. Thus, we could not define an objective measure of "overuse" linked to a specific active ingredient.

The data do show a correlation between high use of personal and field pesticides. This correlation may be the result of seasonal use, so that an increase in pests during one part of the year caused an increase in the use of all pesticides; or the correlation may be the result of location, where those living in the desert and other field environs would be more likely to have used pesticides. It also may be indicative of a reporting bias: People who report high use of one pesticide form are more likely to report high use of another form.

Pesticides and PB Pills

We estimate that approximately 50 percent of the in-theater population, or about 223,500 people, took PB pills at some time during their deployment. Table S.4 shows the usage. Ninety-five percent of the personnel who took PB pills took fewer than three PB pills per day. However, if the respondents' responses are accurate, then 1 percent of the personnel averaged more than three pills per day; in the most extreme cases, seven respondents representing 1,547 personnel reported taking six or more pills per day.

Table S.4
Average Frequency of Use and Percentiles for Frequency of Use Among Those Who Took PB Pills

	Total GW Population (n = 223,501)		Army (n=158,889)		Marines/Navy (n = 48,599)		Air Force (n = 16,012)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average	26	1.7	26	1.7	27	1.7	28	1.9
Percentile								

50	20	2	20	2	20	1	20	2
75	31	2	31	2	31	2	42	3
95	84	3	63	3	84	3	93	3
100	114	9	217	9	224	8	93	6

NOTE: The columns labeled "Times/day" indicate the number of times per day *for the days used.*

In these data, we find a statistically significant positive association between the number of PB pills taken in a month and the total number of applications of personal-use pesticides. In particular, frequency of use of personal-use sprays and lotions was found to be positively associated with of the number of PB pills taken, even after controlling for other important demographic effects.

Figure S.2 demonstrates the association between self-reported frequency of use of personal pesticides and PB pills. The bar shows the percentage of the population who used personal pesticides with a certain frequency. So, for example, about 6 percent of the population applied some combination of personal-use pesticides 120 times or more in a month.[6] The column on the far right shows the average frequency of use of PB pills among those personnel within each group. For example, the 6 percent who applied personal pesticides more than 120 times a month took an average of 19 PB pills in a month. Although the association is relatively modest, the effect of even modest combinations of pesticides and PB pills is not fully understood.

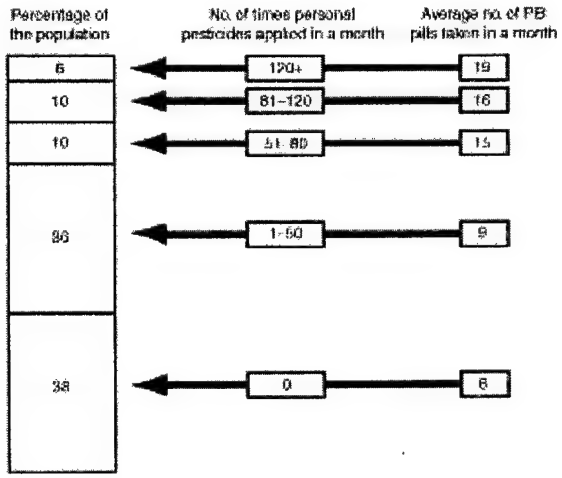

Figure S.2--Frequency of Personal Pesticides Self-Reported Use Compared to Average PB Pill Self-Reported Use

Multiple Pesticides

We previously mentioned animal flea or tick collars as a clear example of pesticide misuse. Other personal-use pesticides are more difficult to evaluate in these terms because there was little information allowing us to judge whether levels of use were inappropriate. Figure S.3 plots the distribution of the population with a particular frequency of use for each form of pesticide. It shows, for example, that about 3 percent of the population used sprays more than 100 times a month, or an average of more than three times a day. For a given individual, if the spray was permethrin, such a frequency of use is in excess of the recommended amount.[7] Similarly, about 5 percent of the population used liquids or lotions more than 100 times a month.

However, Figure S.3 provides information on only one pesticide form at a time. If we consider multiple forms with high use, we estimate that more than 21,000 personnel (4-1/2 percent of the total population) used either sprays more than 120 times a month, liquids more than 100 times a month, or flea collars. Of these, we estimate that slightly more than half (n = 11,064) also took PB pills.

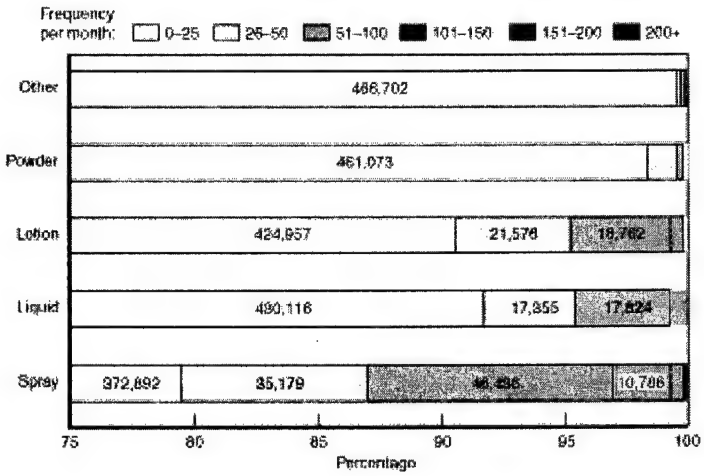

Figure S.3--Frequency of Use of Personal Pesticides by Percentage of the Population

RECOMMENDATIONS

Gambel et al. (1998), in surveys of deployed Army soldiers, found that information about personal protective measures (PPMs) used to prevent arthropod-related diseases and nuisance bites is not incorporated into commonly used soldier manuals or references and they are not routinely trained or tested in their use. They further found that only 40 percent of the personnel surveyed could correctly specify military personal-use pesticide products, more than 90 percent did not treat their uniforms before deployment, and more than 60 percent of personnel used commercial insect repellents. These results are consistent with our findings that respondents generally could not remember the pesticides they used.

Given that limited formal training is provided to military personnel, it should not be surprising that individuals varied in their application and some tended to overapply in the absence of other guidance. Our data and Gambel et al.'s provide ample evidence for recommending the development and implementation of skill training for military personnel in the proper use of PPMs.

We also find that personnel who reported using more pesticides tended to report taking more PB pills, and a few individuals in our sample reported taking an excessive number of PB pills. Golomb (1999) has suggested that pesticides and PB pills may interact over time. If this is found to be true, then further study of PB pills and pesticides is warranted.

CONCLUSIONS

Evaluating misuse, multiple use, and overuse with these data is difficult at best because, even when the respondent could name a pesticide, our conclusions are still inextricably confounded with recall bias and accuracy issues. For example, the cases we found of possible misuse and overuse can be

explained either as true cases of misuse and overuse if one is willing to takes the responses literally. However, information on the possible misuse of field pesticides is as likely or more likely to be examples of incorrect identification or reporting than misuse. The one clear example of misuse is use of flea or tick collars, where there is little question that the respondents correctly identified and reported the pesticide product.

However, the difficulty in teasing these effects out of the survey data should not be taken as evidence that they do not exist. It seems reasonable to expect that individuals who used one pesticide with a high frequency would also be predisposed to use others similarly. It also seems reasonable that people in environments with large numbers of pests, such as in the Persian Gulf, would be tempted to use whatever means was available to remove the pests, including using products in ways not recommended. Indeed, as one respondent said, "anything we could get our hands on we would use."

What is clear from this survey is that a large majority of troops were exposed to some of the pesticides present in the Gulf. It is also clear that smaller groups of personnel had unusual pesticide-use patterns, either misusing or applying unusual quantities. Although we do not find clear evidence of widespread misuse of pesticides--the timing and nature of this survey make finding such results difficult--it still may have occurred. We may have simply been unable to detect it almost a decade after the fact.

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[1]Appropriately de-identified to protect survey participants' anonymity.

[1]http://www.va.gov/health/environ/faq.htm.

[2]Personnel who were located at sea or who only flew over the area were ineligible to participate in the survey.

[3]The Coast Guard was included with the Navy. There were 848 Coast Guard personnel in the Gulf War database and through random sampling we selected five to be interviewed.

[4]Permethrin-based sprays were the only sprays available from the military supply system. However, we found that a majority of personnel used commercial sprays, hence the finding of a large number of DEET-based sprays. The data are consistent with information about the military supply system: For those sprays we could identify positively, 77 percent of permethrin sprays were reported as "military issue;" 66 percent of DEET sprays were not military issue.

[5]Of those who used flea collars, more than one-half wore them over their clothes or shoes, which would have helped minimize exposure to the active ingredient. Thus, the evident misuse may or may not have resulted in overexposure.

[6]DEET was the most commonly used personal pesticide (technically, it is a repellent, not a pesticide). DEET has minimal AChE inhibitory potency. However, since the data are not detailed enough to allow us to determine exactly what each individual used, we can only aggregate all personal pesticide use.

[7]The DoD Repellent System consists of a 31.5 percent DEET lotion (NSN 6840-01-284-3982) and a permethrin spray (NSN 6840-01-278-1336). Instructions on the product state that the DEET lotion "provides 95% or greater protection against mosquitoes for 12 or more hours under normal use

conditions. Instructions on the permethrin product state, "reapply after six weeks and sixth laundering."

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Acknowledgments

We would like to thank The Honorable Bernard D. Rosker, Under Secretary of Defense for Personnel and Readiness and Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, for sponsoring this effort. We would also like to thank Lieutenant General Dale A. Vesser (Ret.), Deputy to the Special Assistant for Gulf War Illnesses; Colonel Michael H. Abreu, USA, Director, Investigations and Analysis Division; and Anne Davis, former Director, Investigations and Analysis Division for their support of this work.

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The original Gulf War database was compiled at the Defense Manpower Data Center (DMDC). Mike Dove and Scott Seggerman of DMDC provided invaluable assistance and quick response to our requests for supplemental data. Anita Lancaster and her staff provided support and guidance on issues related to obtaining the necessary survey approvals.

Last, and certainly not least, we would be remiss if we did not recognize our many RAND colleagues who helped us in this endeavor. These include Gary Cecchine, Ross Anthony, and Beatrice Golomb, who provided many valuable comments on this work and assisted us with some of the finer technical points; Dan McCaffrey, Matt Schonlau, and many other members of the RAND Statistics Group, who were very generous with their time and advice on statistical matters; and, our reviewers, John Adams, Sandra Berry, and Tim Dickens, who provided invaluable guidance through their insightful comments.

Any errors or omissions are the sole responsibility of the authors.

Contents

Acronyms

AChE	Acetylcholinesterase
AFPMB	Armed Forces Pest Management Board
AFSC	Air Force Specialty Code
CASES	Computer Assisted Survey Execution System
CATI	Computer Assisted Telephone Interviewing (system)
CHPPM	Center for Health Promotion and Preventive Medicine
CMAT	Case Management Action Team (OSAGWI)
DEET	Diethyl-m-toluamide
DMDC	Defense Manpower Data Center
DoD	Department of Defense
EPA	Environmental Protection Agency
GIS	Geographic Information System
HSDB	Hazardous Substances Data Bank
KTO	Kuwaiti Theater of Operations
NDRI	National Defense Research Institute
NIOSH	National Institute for Occupation Safety and Health
ODS/DS	Operation Desert Shield/Desert Storm
OMB	Office of Management and Budget
OSAGWI	Office of the Special Assistant for Gulf War Illnesses
PPM	Personal Protective Measures
PB	Pyridostigmine Bromide
RUC	Reporting Unit Code
SRG	Survey Research Group
SRS	Simple Random Sampling
SSN	Social Security Number
TDY	Temporary Duty Assignment
TOXLINE	Toxicological Data Network
UAE	United Arab Emirates
UIC	Unit Identification Code
USA	U.S. Army
USAF	U.S. Air Force
USMC	U.S. Marine Corps
USN	U.S. Navy
USASCURR	U.S. Armed Services Center for Unit Records Research
VA	Veterans Administration
VDM	Veterans Data Management (Team, OSAGWI)

A Note on Trade Names

This report discusses many commercial products with trade names that may be trademarks or registered trademarks. Below, we list the products and the manufacturers who own rights to the trademarks or the trade names.

6-12 Plus®	d-Con Company, Inc.
AIP™	G. S. Building Systems Corporation
Baygon®	Bayer Aktiengesellschaft
Chigg-Away®	Pierson Laboratories, Inc.
Clorox®	Clorox Company
Combat™	American Cyanamid Company
Cutter Gold®	Bayer Corporation
Cutter Insect Repellent®	Bayer Corporation
Deep Woods Off!®	S. C. Johnson & Son, Inc.
Demon™	ICI Americas Inc.
Dursban™	Dowelanco Rofan Services, Inc.
Ficam W®	Fisons Limited Corporation
Flytek™	Sandoz Ag Corporation
Fumitoxin™	G. S. Building Systems Corporation
Hawaiian Tropic®	Tanning Research Laboratories, Inc.
Lubriderm®	Warner-Lambert Company
Maki™	Lipha Chemicals, Inc.
MaxForce™	Kingsford Products Company
Muskol®	Plough Canada Inc.
No-Pest™	Shell Oil Company
OFF!®	S. C. Johnson & Son, Inc.
P.C.Q.®	Bell Laboratories, Inc.
Perma-Dust®	Whitmire Research Laboratories, Inc.
Permanone®	Agrevo Environmental Health, Inc.
Phostoxin™	DEGESCH GMBH
Pival™	Motomco, Inc.
Pyrenone™	Fairfield American Corporation
RAID®	S. C. Johnson & Son, Inc.
Rodent Cake®	Bell Laboratories, Inc.
Rozol™	Lipha Chemicals, Inc.
Sevin™	Union Carbide Corporation

Skin-So-Soft®	Avon Products, Inc.
Skintastic®	S. C. Johnson & Son, Inc.
Snip Flykiller™	CIBA-GEIGY Corporation
Soft Scent™	Blue Ribbon Soap Company, Inc.
Talon G™	ICI Americas Inc.
Teknar™	Sandoz, Ltd.
Ultrathon®	3M Corporation

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Chapter One: Introduction

Since the Gulf War ended in 1991, some veterans of Operation Desert Shield/Desert Storm (ODS/DS) have reported a range of health symptoms and problems. Many of these veterans attribute their poor health to deployment to the Persian Gulf. In response, the Department of Defense (DoD) and the Veterans Administration (VA) have established clinical evaluation programs to diagnose and treat these ailments. As of April 1997, more than 100,000 Gulf War veterans have registered with the VA or the DoD reporting health concerns. Of approximately 75,000 veterans who have been medically examined, about 15,000 have undiagnosed symptoms, which commonly include fatigue, muscle and joint pains, headaches, memory loss, skin rash, diarrhea, and sleep disturbances.[1]

To date, little conclusive evidence has been found to link many hypothesized possible causal agents--including depleted uranium, oil well fire smoke, and stress--to Gulf War illnesses.[2] Among the agents still being investigated are pyridostigmine bromide (PB) pills and pesticides. PB pills were given to personnel in ODS/DS to protect against the nerve agent soman. Overexposure to pesticides can cause symptoms similar to those reported by some Gulf War veterans, but little is known about the use (or misuse) of pesticides by the general in-theater military population during ODS/DS.

Before this survey, logistical information quantifying the amount of military-issue pesticides ordered from the theater of operations and interviews with military preventive medicine personnel and entomologists provided the best available data on pesticides used in ODS/DS. However, that information failed to account for pesticides acquired on the local market in theater, or those used by local contractors hired to apply them. It also fails to account for personal-use pesticides shipped from home to individual soldiers, or pesticides acquired from allied troops.

This survey was commissioned to quantify pesticide use by the average soldier during the Gulf War: Which pesticides were used, who used them, and in what quantities. The purpose of the survey was to augment available information about the extent of pesticide use by the troops, the level of multiple pesticide use, and the duration and frequency of use. We designed the survey to elicit data from veterans about their personal use of pesticides and use they observed by others. The survey was a telephone interview of just over 2,000 veterans, randomly selected to be statistically representative of the entire Gulf War population *on the ground* in the Kuwaiti theater of operations (KTO). This population--referred to in this report as the in-theater Gulf War population--consists of:

- All Army and Marine Corps personnel located in Saudi Arabia, Kuwait, and Bahrain;
- All Air Force personnel located in Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, and Oman; and
- Navy personnel in units that were identified as being ashore in Saudi Arabia, Kuwait, and Bahrain.

The survey solicited specific information about the identification and frequency of use of many possible pesticides, including common personal-use pesticides, unusual personal-use pesticides (such as pet flea collars), and various common and rare field-use pesticides (such as those used in aerial spraying). The pesticide information was elicited in the context of the veterans' living, working, and eating conditions.

BACKGROUND ON THE GULF WAR

On August 2, 1990, Iraqi troops invaded Kuwait. By August 8, the first units of the XVIII Airborne Corps of the U.S. Army began deploying to Saudi Arabia (Schubert and Kraus, 1994). Over the course of the next six months, approximately 697,000 U.S. troops deployed to the Persian Gulf region, including almost 500,000 personnel located on the ground in theater.

Enormous effort was involved in moving, housing, feeding, and caring for this many people. For example, by January 1991, the Army was providing almost 40 million meals per month to feed military personnel in theater. It has been estimated that during the early part of the Desert Shield buildup, 4,000 U.S. soldiers arrived in Saudi Arabia each day (Scales, 1997). Such a rapid force buildup required the equally rapid deployment of a logistical infrastructure to acquire and distribute everything from food, water, and fuel, to ammunition and repair parts, to tents and other living accommodations. Part of that effort involved controlling vermin and insect pests indigenous to the region and pests that were attracted by the influx of a large, temporary military population.

Living conditions in KTO varied greatly. The most basic accommodations were tents and rudimentary shelters typically used by the front-line combat troops; variations with increasing comfort were tent cities with additional amenities, air-conditioned tents with floors, and more urban quarters in Saudi Arabian cities. Similarly, eating, working, and sanitary facilities varied greatly (Schubert and Kraus, 1995).

PESTICIDE USE

In every war and military conflict, combat effectiveness has been significantly reduced by disease, and a large number of diseases can be directly linked to disease-carrying vermin.[3] Not only can these vermin transmit disease, but their bites can result in distracting and demoralizing conditions in addition to serious secondary infections and allergic reactions. For these reasons, pest control is of significant military importance, affecting not only troop morale and welfare but also overall unit combat effectiveness and strength.

Insects and rodents were of particular concern during ODS/DS as potential disease vectors. Pest management in ODS/DS was focused primarily on ground troops.[4] As we mentioned, with roughly one-half million personnel deployed to the region in a very short span of time, under widely varying living, working, and threat conditions, the logistical challenge was large.

During the course of ODS/DS, the military procured and used various pesticides. The authority on pesticides in the U.S. military is the Armed Forces Pest Management Board (AFPMB), which recommends pesticides and pesticide policies for all the services. All military-issue pesticides available during ODS/DS were approved by the U.S. Environmental Protection Agency (EPA). However, it is possible that pesticides other than those recommended by the AFPMB may have been used, since the only pesticides that are considered "unauthorized" are those not approved for use by the EPA (unless otherwise specifically approved by the military). For example, soldiers often supplement military-issue pesticides with commercial products.

Pests of concern in theater and the vicinity included arthropods such as sand flies, "filth flies," black flies, mosquitoes, cockroaches, lice, ticks, scorpions, spiders, and centipedes. These vermin can transmit major diseases such as viral encephalitis, sand fly fever, and leishmaniasis, and can become

an extreme nuisance because of their overabundance.[5] Rodents such as rats, mice, and voles were also of concern as disease vectors and contaminants of food supplies. Table 1.1 lists the pesticides used or potentially used by military units during ODS/DS.

More than 35 types of pesticides and pesticide products were used by military personnel during ODS/DS. None was unique to the military--all are, or were at the time, legally available for civilian use in the United States and other countries. The actual total usage of pesticides by U.S. forces during ODS/DS is unknown, but estimates for pesticides acquired within the military supply system have been made by calculating the amount ordered minus the amount returned. Estimates do not include any pesticides in the possession of units at the outset of ODS/DS or pesticides acquired outside the military supply system. Thus, they do not include any pesticides acquired from the local economy or obtained by individual soldiers on their own. For example, there is anecdotal information that some troops obtained such products as citronella candles from private sources to combat pests. In addition, some units that received pesticides did not use them or shipped them home with their unit (rather than returning them to the supply system). There were also reports of pesticides being left in theater or given to coalition partners.

OSAGWI interviews with Gulf War veterans indicate that other pesticides not listed in Table 1.1 were used by or near U.S. forces during ODS/DS. Personnel with pest control responsibilities, as well as supply and logistics personnel, obtained some insecticide from the local economy in Saudi Arabia, and local firms provided pest control contract services. The extent to which other pesticides were used and the amounts used by specific units could not be determined from existing information.

Table 1.1
Pesticides Used or Potentially Used During ODS/DS

Active Ingredient Product	Synonyms, Trade Names	Target Pests
Allethrin	d-trans-Allethrin	Insects
Aluminum phosphide	Phostoxin, Fumitoxin, AlP	Stored product pests
Azamethiphos	Snip Flykiller, Alfacron	Flies
Bacillus thurengiensis	Teknar	Mosquito larvae
Bendiocarb	Ficam W	Roaches, fleas, ticks, mosquitoes, other arthropods
Boric acid	Whitmire (PT 240) Perma-dust	Insects
Brodifacoum	Talon G	Rodents
Bromadiolone	Maki	Rodents
Carbaryl	Sevin	Ants, fleas, other insects
Chlorophacinone	Rozol	Rodents
Chlorpyrifos	Dursban	Mosquitoes, other insects, ticks, mites
Cypermethrin	Demon	Insects
Deltamethrin		Insects
Diazinon		Insects

Dichlorvos	DDVP	Insects
Diethyl-m-toluamide	DEET, 3M Insect/Arthropod and Cutter Insect Repellents	Sand flies, other insects, ticks
Diphacinone	P.C.Q., Rodent Cake, Di-Blox	Rodents
Ethyl hexanediol		Insects
Hydramethylnon (ANSI)	Combat, MaxForce	Insects
Lindane		Lice
Malathion		Insects
Methomyl	Flytek	Flies
Pentachlorophenol		Fungi
Permethrin	Permanone	Insects
Pet flea and tick collars	Amitraz, carbaryl, chlorpyrifos, methoprene, permethrin, phosmet, propoxur, tetrachorvinphos	Insects and ticks
d-phenothrin		Insects
Pindone	Pival	Rodents
Propoxur	Baygon	Flies, roaches, other insects
Pyrethrum/pyrethrins	Pyrenone	Mosquitoes, flies
Resmethrin		Insects
Sulfur	Chigg-Away	Chiggers (mites)
Valone	Tracking powder	Rodents
Warfarin	O-R-500, Rodex, Final, Erase	Rodents

SOURCE: Modified from the Office of the Special Assistant for Gulf War Illnesses (OSAGWI).

RELATED WORK

Simultaneous with this survey, RAND also was commissioned to conduct a scientific literature review of the possible health effects of pesticides that OSAGWI had determined to be of potential concern in relation to Gulf War illnesses. That companion review addresses the characteristics, toxicity, and possible health effects of the pesticides deemed of most interest by OSAGWI. The review includes several pesticide classes: organophosphates (diazinon, chlorpyrifos, dichlorvos, malathion, and azamethiphos), carbamates (methomyl and propoxur), pyrethroids (permethrin and d-phenothrin), organochlorine (lindane), and DEET. The results of that companion review will be published as part of the RAND publication series: *A Review of the Scientific Literature As It Pertains to Gulf War Illnesses. Volume 8: Pesticides* (Cecchine et al., forthcoming).

ORGANIZATION OF THE REPORT

This report is organized into five main chapters and four appendices. In Chapter Two, we discuss the population we surveyed and the survey instrument in detail. In that chapter we also address the methods we used to aid respondents' recall and describe the second, smaller follow-up survey we fielded to assess recall bias. Chapter Three presents our main finding in multiple tabulations of the

survey data. In particular, it presents tabulations of personal-use pesticides by form and active ingredient and tabulations of field-use pesticides by form. In Chapter Four we examine and discuss variations in pesticide use and, finally, in Chapter Five we examine the question of whether pesticides may have been overused or misused. Four appendices then present the details of the survey instrument, the sampling methodology, our analytic methods, and the details of our recall bias analysis.

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[1]http://www.va.gov/health/environ/faq.htm.

[2]See, for example, Harley et al. (1999); Spektor (1998); and, Marshall et al. (1999).

[3]AFPMB (1996).

[4]Indigenous pests were not considered a significant threat to personnel remaining on naval vessels. It was expected that their exposure was no different than if the personnel had been at sea in any other part of the world; therefore, no special studies of that group were performed.

[5]AFPMB (1996).

Contents
Next Chapter

Chapter Two: Survey and Sample Description

In this chapter, we describe the population we surveyed and the survey instrument in some detail, including how we administered the survey. We also address the methods we used to aid respondents' recall and describe a second, smaller follow-up survey we fielded to assess the reliability of the responses-- in the sense of how much they were subject to change over time. We conclude by discussing the survey response rates.

THE SURVEY SAMPLE

We drew our sample from records of Army, Air Force, Marine Corps, and Navy personnel who were reported to have served in ODS/DS between August 1, 1990, and July 31, 1991. We focused on the subset of personnel who served *on the ground* (as opposed to personnel who were located at sea in the Persian Gulf or who only flew over the area) in the KTO. Personnel who were ultimately eligible to be surveyed consisted of:

- Army and Marine Corps personnel located in Saudi Arabia, Kuwait, and Bahrain;
- Air Force personnel located in Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, and Oman; and
- Navy personnel in units that could be identified as being ashore in theater.[1]

To identify personnel meeting these criteria, we used data supplied by the U.S. Armed Services Center for Unit Records Research (USASCURR) with assistance from OSAGWI and the Center for Health Promotion and Preventive Medicine (CHPPM). In brief, we augmented a database of personnel who were in ODS/DS originally compiled by the Defense Manpower Data Center (DMDC) with information linking persons to units and units to locations. From this combined database, personnel in units that were not located in theater between August 1, 1990, and July 31, 1991, were ineligible to be sampled. We erred on the side of inclusion, since exclusion was dependent on known ineligibility. Personnel who could not be linked to units, or who were in units that could not be linked to locations, remained eligible to be sampled.

The sample was stratified by branch of service, occupational specialty, rank, and unit location. We stratified in these dimensions to (1) achieve equal precision in the estimates across services, and (2) to interview sufficient numbers of personnel with special knowledge or special living conditions. In particular:

- **Military Service.** *There were three service strata: (1) Army, (2) Air Force, and (3) Marine Corps and Navy.* In-theater Navy personnel were included in the Marine Corps stratum because there were too few to justify a separate stratum. Personnel in the second and third strata were oversampled so estimates by service group would have approximately the same precision. Without oversampling, the Army would have dominated the sample, since they constituted 65 percent of the personnel on the ground in theater.
- **Special Knowledge.**[2] *Food service occupational specialties have special knowledge of pesticide use in mess halls (dining facilities), where improper pesticide use could contaminate meals.* Food service occupational specialties were oversampled because they constituted only

about 2 to 3 percent of the force in theater.

- **Rank**. *Senior enlisted personnel were likely to have a broader knowledge of how pesticides were used.* However, the majority of personnel in the Gulf were junior enlisted; only about 18 percent of the personnel were senior enlisted. Senior enlisted personnel, defined as E-6 to E-9, were therefore oversampled.

- **Location**. *Personnel living in urban areas were likely to have had different pest problems from those living in tents and other accommodations.* Since only approximately 26,000 personnel were linked to units located in or near urban areas, they were oversampled.

In all, 3,264 records were sampled from 536,790 eligible records, evenly divided across the Army, the Air Force, and the Marine Corps combined with the Navy. Additional details on the specific definition of the sampling frame, the sample selection methodology, and oversampling are contained in Appendix B.

DESCRIPTION OF THE MAIN SURVEY INSTRUMENT

We designed the survey instrument around two primary objectives:

- Collecting appropriate data to identify and quantify pesticides used during ODS/DS; and

- Enhancing valid recall of events while limiting biases and distortions to memory that could result from the eight- to nine-year lapse between events and the survey itself.

Our definition of "appropriate data" was driven by the determination of what information would be necessary to accurately portray use and exposure levels. We also carefully organized and presented the survey questions so that veterans' memories of pesticide details from eight to nine years prior would be most likely to sharpen during the interview.

We conducted an extensive literature review of other retrospective studies to evaluate survey methods used to reduce recall bias. This review and its findings, in combination with the insight gained from our initial pretests, guided the survey's final organization and grouping of topics. Table 2.1 outlines the instrument. Appendix A provides additional details about the survey instrument design process, and Appendix D provides additional details and a complete discussion of the recall bias results.

Table 2.1
Survey Instrument Outline

Module I: Introduction and Screener
Respondent verification
Informed consent, privacy statement, and confidentiality pledge
Assessment of general awareness of Gulf War issues to measure recall bias
Module II: One Month in the Persian Gulf
Month chosen at random
Reminder given of landmark events in that month
Data on physical environment collected

Module III: Pest Problems and Pesticide Use
List of pests respondent encountered in Gulf
Record form of pesticides respondent used on body or uniform
Record details of use by individual pesticide form and product
Record form of pesticides respondent and others used around physical environment
Record details of use by individual pesticide form and product

Module IV: Background Questions
Used to explore patterns of differential response
Data on other respondent demographics collected

Instrument Format and Branching

We organized the survey instrument into three primary sections: (1) a description of each respondent's physical environment; (2) the personal use of pesticides by respondents on their bodies or uniforms; and (3) the field use of pesticides in their personal environment by the respondent or others. Each respondent was asked to provide this information for a randomly chosen month during his or her service in theater. The three sections were preceded by an introduction and a series of identity verification questions and followed by concluding questions regarding respondent education and willingness to take part in a follow-up survey.

The survey was designed to be completed in 30 minutes on average. To achieve this, we had to make a tradeoff between collecting detailed data for a specific, short time frame or collecting more general data about the respondent's entire ODS/DS experience. To collect the most information possible that still allowed extrapolation to the entire ODS/DS period, we chose to select one month at random out of each respondent's tour, creating a cumulative database of detailed information across respondent experiences.

We specifically organized the instrument to trigger memories of the time period by asking respondents first to visualize their location during the randomly selected month, then by asking specific questions regarding their living quarters, bathroom facilities, eating arrangements, and work areas. Not only was this preliminary information of interest to us in our analysis, but it also served to set the scene for respondents, preparing them for the more detailed questions regarding their pesticide use by setting up the contextual memory on which they could draw at the outset of the interview.

Using primarily the feedback of pretest respondents, we organized the questions so that information was first collected on the various pesticide forms used. We then asked specific questions addressing each form indicated by the respondent. Personal and field-use pesticides were queried separately in this same format. This approach paralleled the way respondents recollected their use of pesticides: First the various products were listed, then each type and its use were described.

Elicitation of Pesticide Information

We conducted this survey between May and October 1999. Considering that it was fielded years after the end of ODS/DS, we had little expectation that respondents would be able to recall the names of all the products used, especially those used in the field. In fact, Gambel et al. (1998) indicate that

Army soldiers deployed in Kuwait, Haiti, and Bosnia had difficulty identifying military-issue personal-use pesticides even during their deployment. To overcome this challenge, we developed a strategy in the pretest rounds in which respondents could focus primarily on the forms of the pesticides throughout the survey, rather than on their names. This method of questioning proved to be effective: Most veterans were easily able to recall the forms of the pesticides used during the war and were consequently able to discuss further details surrounding their use (when perhaps the particular names of the pesticides were not known). Based on the responses of pretest veterans, the forms included in the final survey were lotions, sprays, powders, liquids, flea collars, small solids (specifically, pellets, crystals, and granules), and "other." For each form a respondent indicated using, the pesticide name was first solicited either by active ingredient or by trade names. If the name could not be recalled, a description of each active ingredient was then solicited in terms of its color and smell.

The list of possible smells was constructed by including all the smells that characterize the different pesticides[3] shown in Table 2.2. These were cooking oil, rotten eggs or sulfur, gasoline, insecticide, kerosene, chemical, sweet, and musty. Similarly, the colors were defined as colorless/clear, light brown, dark brown, gray, orange, red, white, opaque/cloudy/milky, and yellow. Both color and smell allowed the respondent to choose multiples and to add other comments. The combination of form, color, smell, and the location where the pesticide was used can often be used to specify a unique active ingredient.

We separately grouped the possible uses of pesticides into those for personal use and those for field use. Personal-use pesticides were defined as those used directly on the skin or uniform by the respondent. For field-use pesticides, the user could have been either the respondent or another individual observed by the respondent.

The specific pesticides used by or near the respondent depended on the type of location where she/he spent most of the time during the period in question and on the type of pests present. Some pesticides were used only indoors, others only outdoors, others in latrines, etc. Some were used on the skin and others on uniforms or netting only.

We divided the types of geographical locations where people spent most time while in the Persian Gulf into the following categories:

- An urban area where tents were not used for living quarters;
- A semipermanent military tent city;
- A U.S. military airbase;
- A non-U.S. airbase;
- The desert away from cities, air bases, and semipermanent tent cities; and
- Another type of place (further description requested).

Within these categories, there were different types of facilities where people slept, ate, and worked. These places are listed in Table 2.2, along with the possible pesticide list used to code smells and colors.

Table 2.2
Possible Pesticides Used in Different Types of Situations

Situation Type	Possible Pesticides Used
Sleeping or working areas	
Building or warehouse	Allethrin/permethrin/resmethrin, azamethiphos, cypermethrin, deltamethrin, dichlorvos, diphacinone, methomyl, d-phenothrin
Tent	Allethrin/permethrin/resmethrin, azamethiphos, dichlorvos, diphacinone, methomyl, d-phenothrin, valone
Military vehicle	Azamethiphos, diphacinone, methomyl, valone
Outdoors	Aluminum phosphide, azamethiphos, B.T., carbaryl, cypermethrin, deltamethrin, diazinon, lindane, malathion, methomyl, parathion, propoxur, pyrethrin, valone
Other places	
Mess hall/eating area	Allethrin/permethrin/ resmethrin, azamethiphos, chlorpyrifos, diazinon, dichlorvos, diphacinone, malathion, methomyl, d-phenothrin, propoxur, valone
Latrine	Azamethiphos, chlorpyrifos, dichlorvos, diazinon, malathion, methomyl, d-phenothrin, propoxur, valone

SOURCE: OSAGWI.

For each pesticide used by the respondent, we asked questions about where it was obtained, its frequency of use, and, if they stopped using it, the reason. For the nonliquid/nonspray pesticides, we also recorded information on disposal.

For the field use of sprays, we recorded information on the type of sprayer used (hand-held, truck, or plane fogger[4]) as well as the areas sprayed (indoors, outdoors, outside the camp perimeter, and specific areas inside the camp).

Advance Recall Aids

We sent a letter to each respondent in advance of the interview explaining the study's purpose, its sponsor, and what the interview would be covering. We also enclosed a brochure with answers to frequently asked questions and materials we developed to aid recall. These materials included a map of the Persian Gulf, a calendar with key events highlighted for the months August 1990 through July 1991--key events that respondents could use to bound experiences during their tour--and a Gulf War Service Fact Sheet (mimicking questions from Module I) to be filled out in advance of the interview.[5] This fact sheet, in addition to the other materials, was intended to initiate recall of the respondent's tour in advance of the interview.

Assessing Recall Bias Through Re-Survey

We also randomly selected a subset of 8 percent of the respondents who agreed to be reinterviewed with selected questions from the original survey to assess the reliability of answers about exposure to pesticides during ODS/DS. We administered the second survey after about six weeks, during which

time respondents were generally expected to forget, at least in part, how they had answered the first survey. In this way, we were able to examine what fraction of their answers changed. The interpretation of this change can be ambiguous, but re-testing helped us to assess how reliable the answers were over time.

We administered the recall survey to a random subsample of the original respondents.[6] We re-asked the location and timeline questions to reestablish context, and then asked about the types of personal and field uses of pesticides respondents participated in or observed. If they indicated a pesticide type that matched something they listed the first time, we continued with the more detailed questions about names, sources, and frequency of use. (If there was no match, we had no data to compare against and so did not collect additional information.)

MODE OF DATA COLLECTION

We administered the surveys by telephone via a centralized telephone interviewing facility located in RAND's Santa Monica, California, office. It was designed for use with the Berkeley computer assisted telephone interviewing (CATI) system, making online data collection possible. RAND's CATI system is run using a current version of Berkeley's computer assisted survey execution system (CASES). The CATI system displays each interview question on the computer screen for interviewers to read, and allows direct entry of responses into the computer database at the time of the interview, while employing real-time edit and logic checks. It facilitates implementation of complex survey designs such as this one, because it can quickly determine sample eligibility, provide appropriate skipping and branching routines, and tailor question wording to respondent characteristics or previous answers. The system includes sample management as well as automatic call scheduling and case delivery. This allowed our interviewing staff to maintain the status of each case in the sample and to work the sample efficiently according to survey priorities and scheduled appointments. Some respondent tracking was also done with the help of this system. The central monitoring system enabled both audio and visual "real time" monitoring of interviews in progress, both for quality control and interviewer guidance.

INTERVIEWER TRAINING

Interviewers participated in ten days of structured training, with an additional week allowed for unstructured CATI practice before initiating calls. During training, interviewers were instructed in survey interviewing methodology, in the use of the CATI system, in basic tracking methods, and in specific details relating to the interviewing of Gulf War veterans and issues surrounding the study. Interviewers were required to pass a checkout interview with a mock respondent before they were allowed to proceed with calling. Over the course of the study, 20 percent of all interviews were monitored by a supervisor for quality control purposes.

In addition, once the study was under way, an interviewer specialist was trained in refusal conversion. This person followed up with all respondents who had previously refused participation, in an effort to better inform them of the nature of the project and give them another chance to participate. Of those recontacted, approximately 70 percent agreed to the interview.

RESPONDENT COOPERATION AND RESPONSE RATES

Gulf War veterans were very cooperative with the survey effort. Only 4 percent of the veterans contacted refused to participate. Of those interviewed, the RAND interviewers rated cooperation as

"good" to "very good" for 95 percent of the respondents; less than 1 percent were rated as "poor" to "very poor." Similarly, interviewers rated almost 97 percent of the respondents' interest in the survey as "average" to "very high."

Response and nonresponse rates are summarized in Table 2.3. The interviewers were able to contact 76 percent of the personnel in the initial sample. Interviews were completed for 2,005 out of the original 3,264 personnel selected.

Table 2.3

Survey Response Rates

Response Status	Percentage of Subgroup	Percentage of Sample
Respondent not in Gulf War		7
Interview completed		61
Respondent located, no interview		
Not interviewed	3	
Refused interview	3	
Unable to respond	2	
Total		8
Respondent not located		
Full tracking	14	
Reduced tracking	9	
Total		23
Other		1

NOTE: The original sample size was 3,264.

In all, only 3 percent of the sampling frame refused to participate, or about 4 percent of those contacted. Two percent were deceased or not able to respond--deployed active duty personnel, for example, often could not respond. Another 7 percent of the personnel in the sampling frame were actually reached but indicated that they had not served in ODS/DS.

As we anticipated, the most common reason for nonresponse was an inability to locate the individual. A detailed and disciplined approach was undertaken to find as many personnel in the sampling frame as possible. However, in spite of these efforts, 23 percent could not be located before the conclusion of the interview period. Individuals who were in the Air Force during ODS/DS were easier to locate than those in the other services. Retired personnel were easier to locate than personnel still on active duty or in the reserves, and civilians were harder to locate. Finally, minorities and females were more difficult to locate than white males.

RESPONDENT AND POPULATION DEMOGRAPHICS

Table 2.4 shows the demographic characteristics of the survey respondents and the entire Gulf War population on the ground in theater. The first column, "Survey Respondents," contains the statistics

for the 2,005 survey respondents. The "Population Estimates" column contains the statistics after the respondents are statistically adjusted to reflect the population of interest. As we discuss in Appendix C, the adjustments account for oversampling, nonresponse, and other phenomena. One specific adjustment we made was for personnel listed in the ODS/DS database but who did not serve in theater. As a result, we estimate that of the 536,790 personnel in the sampling frame, only 469,047 were actually in ODS/DS. This represents a population error rate of about 12 percent,[7] although this rate varies by particular characteristics such as service.[8]

Table 2.4

Sample and Population Demographics

Demographics	Survey Respondents (n = 2,005)	Population Estimates (n = 469,047)
Gender		
Male	94.1	92.6
Female	5.7	6.7
Unknown	0.3	0.7
Service		
Air Force	36.0	14.7
Army	32.5	65.0
Coast Guard	0.1	<0.1
Marine Corps	27.8	18.2
Navy	3.6	2.0
Food service		
No	90.8	97.2
Yes	9.2	2.5
Builtup area		
No	84.4	94.4
Yes	15.6	5.4
Rank		
E-1 to E-3	14.4	16.6
E-4 to E-5	44.0	54.1
E-6 to E-9	30.7	17.8
Enlisted, unknown	0.3	0.7
Officer	10.6	10.8
Race		
Caucasian	72.6	67.4
African-American	18.3	24.5
Hispanic	4.8	4.0
Other	3.7	4.3
Unknown	0.5	0.3

NOTE: Totals may not sum to 100 percent because of rounding.

An analysis of those who said that they were not in ODS/DS shows that: (1) junior enlisted and female personnel (in the database) were less likely to have served in ODS/DS, and (2) personnel who were located in urban areas or had food service occupations were more likely to have been correctly listed as being in ODS/DS.

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[1]Coast Guard personnel were also included in the sampling frame and two members of the Coast Guard were actually surveyed. (Five were originally selected to be interviewed. Of these, two were located and interviewed, two more were located but did not meet the survey eligibility criteria, and one could not be located.) Their results are not included in the tabulations because the results could not be generalized to the Coast Guard population on the ground, in theater. However, we carefully read these respondents' responses individually and found nothing unusual. These two personnel used typical pesticides in typical ways with typical frequency.

[2]We did not oversample preventive medicine personnel, who have had special training and have knowledge of pesticides, as they had been previously separately interviewed by OSAGWI.

[3]Colors and smells were derived from NIOSH (1997); the Merck Index, 12th edition; Hazardous Substances Data Bank (HSDB) (sponsored by the National Academy of Medicine); and Toxicological Data Network (TOXLINE) (sponsored by the National Academy of Medicine).

[4]Although the best information available indicates that aerial spraying was never authorized or used, we included the category for completeness and as an external validation of official reports.

[5]Examples of these materials can be found in Spektor et al. (forthcoming).

[6]More precisely, we administered the recall survey to a random subset of those who agreed to be recontacted. However, 97.4 percent of those surveyed the first time agreed to be recontacted.

[7]The population error rate differs from the sample error rate of 7 percent (Table 2.3) because of weighting. The difference occurs because the sample respondents who did not serve had higher weights than those who did; hence the population percentage is larger than the sample percentage.

[8]Also, note that this 12 percent error rate does not capture the reverse type of error: personnel who served in the Gulf War but are *not* in the Gulf War database. From our survey, we have no way of quantifying this type of error.

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Chapter Three: Survey Results

In this chapter, we present the major results of the survey in tables summarizing the findings by pesticides' form and active ingredient. We begin with a general discussion of our recall bias findings. Then we describe the pests that were observed and summarize the differences in pesticide form use in the services. We then present detailed tabulations for each form of personal- and field-use pesticide asked about in the survey.

Unless otherwise indicated, the proportions and percentages presented in this chapter are our best estimates--based on the 2,005 survey respondents' responses--for the 469,047 in-theater Gulf War personnel on the ground.[1]

RECALL BIAS RESULTS

As described in Chapter Two, we administered a second survey to a small sample (n = 193) of initial survey respondents, in order to study potential recall bias. In particular, the second survey assessed the stability of respondents' answers over time. Appendix D provides the details of our analysis. We summarize the relevant findings here to put the main survey results in the proper context.

Overall, we found that the types of pesticides reported increased in the re-survey by about 13 percent, largely because of increased reporting of field-use pesticides such as No-Pest strips or sprays. Answers about use of personal pesticides, such as number of sprays used or how many times a spray was used, were stable across the surveys.

We also examined the data to see if some groups changed their answers more than other groups. We did not find strong patterns by education, rank, self-reported health status, or a number of other factors. The only group whose answers changed in statistically significant ways for all three variables were junior enlisted personnel (pay grades E-1 to E-5), who remembered more pesticides, both personal and field use. A "worst case" interpretation of these findings is that the incidence of pesticides reporting may have been underestimated in the initial survey but that the effect is not large. Thus, the results presented in this chapter could be considered conservative, in the sense that they may underestimate the fraction of the population that used each form.

PESTS AND PESTICIDES

We found that personnel in the Gulf encountered a wide variety of pests, often in significant concentrations. The percentage of the population that observed various types of pests is given in Table 3.1. As discussed in the previous section, this is the one area in which veterans tended to initially overestimate and, upon further reflection, remembered fewer types of pests. Even so, it is clear that many types of pests were quite commonly present.

Fly swarms were ubiquitous throughout the region--93 percent of the population experienced them. Veterans relate that there were so many flies that it was often difficult to eat. Roughly half of the population also experienced other flying insects, most notably mosquitoes. Crawling pests were widespread, with a majority of the population experiencing scorpions, spiders, and ants. Rodents were also quite frequent, with half the population reporting them.

Table 3.1 also shows that members of each service had relatively similar pest encounters. Somewhat

fewer Marines and Navy personnel reported spiders, mosquitoes, and, fleas,[2] whereas more Air Force personnel reported spiders and roaches, and fewer rodents, lice, and ticks. All these differences were statistically significant. The only pests without statistically significant differences among the service groups were ants, wasps, centipedes, and "other."

Table 3.1
Percentage of Gulf War Veterans Who Reported Seeing Each Type of Pest for the Total Population and by Service

	Percentage (s.e.)[a]			
Pest	All Services	Army	Marine Corps/Navy	Air Force
Flies	93(1)	95(1)	90(1)	91(1)
Scorpions	69(2)	71(2)	65(2)	62(2)
Spiders	61(2)	62(2)	52(2)	71(2)
Rodents	52(2)	52(2)	55(2)	46(2)
Ants	45(2)	45(2)	44(2)	48(2)
Mosquitoes	45(2)	48(2)	37(2)	44(2)
Fleas[b]	44(2)	46(2)	37(2)	45(2)
Other pests	35(2)	37(2)	30(2)	32(2)
Centipedes	26(1)	27(2)	26(2)	25(2)
Roaches	16(1)	14(2)	17(2)	27(2)
Lice	11(1)	12(2)	10(1)	6(1)
Ticks	11(1)	13(2)	8(1)	5(1)
Wasps	10(1)	10(1)	10(1)	10(1)
No pests	1(<1)	1(<1)	1(<1)	1(<1)

[a]"s.e." stands for "standard error," a commonly used statistical measure of the variability of the estimated quantity. The larger the standard error, the greater the actual (unknown) value for the population may deviate from the value estimated from the survey data. It is accepted practice to consider that the true value is highly likely to be within two standard errors of the estimated value. Thus, in this table, although we estimate that 95 percent of Army personnel saw flies, we expect the true but unknown percentage to be between 93 and 97.

[b]Fleas were actually very rare in this region. Service members often referred to "sand fleas," but there is no such species. The pests were probably phlebotomine sand flies, which are so small they could have been confused with fleas when they bite.

Although not shown in Table 3.1, there were also statistically significant differences for some pests among personnel in urban locations and in food service occupations. In particular, personnel in urban locations were more likely to have seen roaches (28 percent) and wasps (14 percent) and less likely to have seen scorpions (55 percent) and "other" pests (27 percent). Food service personnel were more likely to report flies (97 percent) and scorpions (82 percent), and less likely to report ants (36 percent).

Table 3.2 shows the percentage of personnel who reported each form of

personal-use pesticide and Table 3.3 shows the percentage who reported each form of field-use pesticide. Use of personal pesticides clearly differed by service more than the reports of pests. The only form that was not significantly different was the flea collar. In particular, Air Force personnel were less likely to use all forms of personal pesticides, and Army personnel much more likely to use powders. Over one-third of the population did not use any personal pesticides.

Table 3.2
Percentage of Gulf War Veterans Who Used Each Form of Personal Pesticide for the Total Population and by Service

	Percentage (s.e.)			
Pest	All Services	Army	Marine Corps/Navy	Air Force
Spray	44(2)	48(2)	38(2)	36(2)
Lotion	26(2)	28(2)	23(2)	19(2)
Liquid	23(1)	25(2)	24(2)	9(1)
Powder	7(1)	10(2)	2(1)	1(1)
Flea collar	3(1)	3(1)	3(1)	1(1)
Other form	2(<1)	1(1)	1(<1)	4(1)
None	38(2)	33(2)	43(2)	52(2)

Table 3.3 shows that statistically detectable differences between field-use pesticides occurred between services for all forms of field-use pesticides except pellets, No-Pest strips, and "other." In particular, the Marine Corps/Navy showed much lower observed use of aerosols, whereas the Air Force observed a higher use of other sprays and a lower observed use of liquids. About one-half of the total population did not use or observe any field pesticides.

Table 3.3
Percentage of Gulf War Veterans Who Used or Observed the Use of Each

Form of Field Pesticide for the Total Population and by Service

	Percentage (s.e.)			
Pest	All Services	Army	Marine Corps/Navy	Air Force
Aerosol	28(2)	31(2)	20(2)	27(2)
Other spray	20(1)	15(2)	23(2)	36(2)
Powder	13(1)	15(2)	12(2)	8(1)
Pellets, etc.	12(1)	12(2)	10(1)	11(1)
No-Pest strips	7(1)	7(1)	5(1)	6(1)
Liquid	4(1)	4(1)	5(1)	1(<1)
Other form	3(1)	3(1)	3(1)	3(1)
None	51(2)	49(2)	57(2)	50(2)

PERSONAL PESTICIDE TABULATIONS

This section presents our summary tabulations of personal pesticide use. We were able to tabulate personal-use pesticides in two ways: (1) by common active ingredients, and (2) by form. The next section presents tabulations for field pesticides by form only because most respondents could not provide sufficient identifying information. These tabulations (and the subsequent field-use tables) represent the fundamental survey results. .

Personal-Use Pesticide Tabulations by Form

In Tables 3.4 to 3.9, we quantify the reported usage by the various forms of personal-use pesticides, including sprays, liquids, lotions, powders, flea collars, and "other" forms. These tables contain our best estimates of use from the survey data for the entire in-theater Gulf War population. In the tables we list:

Table 3.4

Tabulations for the Use of Personal Sprays by Self
(possible active ingredients include DEET, permethrin)

Percentage (s.e.) Who Used Personal Sprays

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
44(2)	48(2)	38(2)	36(2)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used Personal Sprays[a]

	Total GW Population (n = 207,414)		Army (n= 146,101)		Marines/Navy (n = 36,334)		Air Force (n = 24,981)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average	45(2)	2(<1)	46(3)	2(<1)	47(4)	2(<1)	38(3)	2(<1)
Percentile								
5	4	1	4	1	4	1	2	1
25	10	1	14	1	10	1	8	1
50	30	2	30	2	30	2	28	1
75	60	3	63	3	60	3	60	3
95	150	6	150	6	153	6	150	6
100	450	12	360	12	360	12	450	8
Unknown	15	11	16	11	15	12	14	10

[a]The columns labeled "Times/day" indicate the number of times per day *for the days used.*

Source of Pesticides Among Those Who Used Personal Sprays

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	69(2)	72(3)	58(4)	69(3)
From PX	24(2)	23(3)	31(3)	18(3)
From United States	25(2)	24(3)	29(3)	25(3)
Fellow U.S. soldiers	18(2)	18(3)	21(3)	17(3)
International soldiers	5(1)	5(2)	3(1)	6(2)
Other source	1(<1)	1(<1)	2(1)	2(1)
Don't know	2(1)	1(1)	2(1)	1(1)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used Personal Sprays

	Total Population	Army	Marines/Navy	Air Force
Number of different sprays used, # (s.e.)	1(<1)	1(<1)	1(<1)	1(<1)
Where used, % (s.e.)				
Body	9(2)	8(2)	10(2)	10(2)
Uniform	29(2)	28(3)	30(3)	33(3)
Body and uniform	68(2)	69(3)	66(3)	65(3)
Reasons for ceasing use, % (s.e.)				
Pests stopped being a problem	13(2)	12(2)	13(2)	16(3)
Ran out of pesticides	16(2)	18(3)	16(3)	10(2)
Another reason	13(2)	12(2)	15(2)	14(3)
Side effects, % (s.e.)				
Reported experiencing side effects	10(1)	9(2)	11(2)	10(2)
Stopped using or reduced amount because of side effects	5(1)	5(1)	6(2)	3(1)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers or because of rounding.

Table 3.5

Tabulations for the Use of Personal Liquids by Self
(possible active ingredients include DEET, permethrin, benzocaine)

Percentage (s.e.) Who Used Personal Liquids

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
23(1)	25(2)	24(2)	9(1)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used Personal Liquids[a]

	Total GW Population (n = 105,425)		Army (n= 75,844)		Marines/Navy (n = 23,104)		Air Force (n = 6,476)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average	35(2)	(<1)	36(3)	2(<1)	35(3)	2(<1)	30(4)	2(<1)
Percentile								
5	2	1	2	1	4	1	2	1
25	8	1	8	1	8	1	8	1
50	30	1	30	2	30	1	16	1
75	60	2	63	2	60	2	30	2
95	120	4	120	5	92	4	96	4
100	180	6	180	6	122	6	152	6
Unknown	9	6	9	6	11	5	11	6

[a]The columns labeled "Times/day" indicate the number of times per day *for the days used.*

Source of Pesticides Among Those Who Used Personal Liquids

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	92(2)	92(3)	91(3)	87(5)
From PX	3(1)	2(1)	6(2)	4(3)
From United States	6(2)	7(2)	5(2)	8(4)
Fellow U.S. soldiers	13(2)	12(3)	17(4)	9(4)
International soldiers	1(1)	1(1)	2(1)	3(3)
Other source	<1(<1)	0	1(1)	0
Don't know	1(<1)	<1(<1)	1(1)	2(2)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used Personal Liquids

	Total Population	Army	Marines/Navy	Air Force
Number of different liquids used, # (s.e.)	1(<1)	1(<1)	1(<1)	1(<1)
Where used, % (s.e.)				
Body	56(4)	53(5)	61(5)	67(6)
Uniform	6(2)	6(3)	5(2)	8(4)
Body and uniform	39(4)	41(5)	36(4)	25(6)
Reasons for ceasing use, % (s.e.)				
Pests stopped being a problem	14(3)	14(3)	17(3)	12(4)
Ran out of pesticides	9(2)	7(2)	12(3)	13(4)
Another reason	17(3)	19(4)	13(3)	12(4)
Side effects, % (s.e.)				
Reported experiencing side effects	12(3)	13(3)	9(3)	10(4)
Stopped using or reduced amount because of side effects	4(2)	4(2)	4(2)	7(3)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers or because of rounding.

Table 3.6
Tabulations for the Use of Personal Lotions by Self
(possible active ingredients include DEET, benzocaine)

Percentage (s.e.) Who Used Personal Lotions

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
26(2)	28(2)	23(2)	19(2)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used Personal Lotions[a]

	Total GW Population (n = 120,460)		Army (n= 85,729)		Marines/Navy (n = 21,413)		Air Force (n = 13,318)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average	45(2)	2(<1)	46(3)	2(<1)	47(4)	2(<1)	38(3)	2(<1)
Percentile								
5	2	1	2	1	2	1	2	1
25	8	1	8	1	10	1	5	1
50	20	1	16	1	27	1	15	1
75	30	2	60	2	30	2	30	2

95	90	4	114	4	90	4	87	4
100	180	8	180	7	132	8	147	6
Unknown	6	4	5	3	9	6	9	6

[a]The columns labeled "Times/day" indicate the number of times per day *for the days used.*

Source of Pesticides Among Those Who Used Personal Lotions

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	84(2)	88(3)	79(4)	69(5)
From PX	5(1)	3(1)	12(3)	6(2)
From United States	8(2)	6(2)	13(3)	8(3)
Fellow U.S. soldiers	16(2)	12(3)	26(4)	21(4)
International soldiers	2(1)	2(1)	3(2)	3(2)
Other source	2(1)	2(1)	1(1)	2(2)
Don't know	1(<1)	1(1)	1(1)	2(1)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used Personal Lotions

	Total Population	Army	Marines/Navy	Air Force
Number of different lotions used, # (s.e.)	1(<1)	1(<1)	1(<1)	1(<1)
Where used, % (s.e.)				
Body	86(2)	86(3)	85(3)	87(3)
Uniform	<1(<1)	<1 (<1)	<1(<1)	1(1)
Body and uniform	14(2)	14(3)	16(4)	12(3)
Reasons for ceasing use, % (s.e.)				
Pests stopped being a problem	17(3)	17(3)	18(4)	16(4)
Ran out of pesticides	7(1)	6(2)	13(3)	6(3)
Another reason	18(3)	19(4)	15(3)	21(4)
Side effects, % (s.e.)				
Reported experiencing side effects	8(2)	8(2)	9(3)	11(3)
Stopped using or reduced amount because of side effects	5(2)	5(2)	5(2)	9(3)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers or because of rounding.

Table 3.7
Tabulations for the Use of Personal Powders by Self
(possible active ingredients include lindane)

Percentage (s.e.) Who Used Personal Powders

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
7(1)	10(2)	2(1)	1(1)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used Personal Powders[a]

	Total GW Populations (n = 33,790)		Army (n= 30,860)		Marines/Navy (n = 1,956)		Air Force (n = 974)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average	21(3)	1(<1)	20(3)	1(<1)	39(12)	2(<1)	10(5)	1(<1)
Percentile								
5	2	1	2	1	3	1	1	1
25	5	1	7	1	8	1	3	1
50	16	1	16	1	30	1	8	1
75	30	2	30	2	31	2	12	1
95	80	3	80	3	120	4	30	2
100	150	5	150	5	120	4	30	2
Unknown	5	5	4	4	22	22	0	0

[a]The columns labeled "Times/day" indicate the number of times per day *for the days used.*

Source of Pesticides Among Those Who Used Personal Powders

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	88(5)	88(5)	93(7)	68(18)
From PX	7(4)	8(4)	0	0
From United States	5(3)	6(4)	0	0
Fellow U.S. soldiers	13(5)	10(5)	33(14)	41(19)
International soldiers	1(1)	1(1)	0	0
Other source	3(2)	3(3)	0	0
Don't know	1(1)	1(1)	0	0

NOTE: Columns may sum to more than 100 percent because respondents could give multiple

answers.

Details of Use Among Those Who Used Personal Powders

	Total Population	Army	Marines/Navy	Air Force
Number of different powders used, # (s.e.)	1(<1)	1(<1)	1(<1)	1(<1)
Where used, % (s.e.)				
Body	28(7)	30(7)	13(10)	0
Uniform	31(7)	31(7)	18(12)	72(16)
Body and uniform	41(7)	40(8)	69(14)	28(16)
Reasons for ceasing use, % (s.e.)				
Pests stopped being a problem	4(2)	3(2)	8(7)	30(18)
Ran out of pesticides	23(7)	24(7)	23(13)	1(2)
Another reason	22(6)	22(7)	14(10)	22(14)
Side effects, % (s.e.)				
Reported experiencing side effects	13(5)	14(6)	3(3)	0
Stopped using or reduced amount because of side effects	9(4)	9(5)	3(3)	0

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers or because of rounding.

Table 3.8
Tabulations for the Use of Flea or Tick Collars by Self
(possible active ingredients include carbaryl, permethrin, chlorpyrifos, propuxor)

Percentage (s.e.) Who Used Flea or Tick Collars

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
3(1)	3(1)	3(1)	1(1)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used Flea or Tick Collars

	Total GW Population (n = 13,291)	Army (n= 9,745)	Marines/Navy (n = 2,606)	Air Force (n = 940)
	Times/mo	Times/mo	Times/mo	Times/mo
Average	21(2)	21(3)	21(3)	15(4)
Percentile				
5	2	3	1	1
25	14	14	14	8

50	26	26	30	20
75	30	30	30	30
95	30	30	30	30
100	30	30	30	30
Unknown	6	8	1	0

Source of Pesticides Among Those Who Used Flea or Tick Collars

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	6(3)	7(4)	0	15(10)
From PX	37(10)	41(13)	14(9)	53(17)
From United States	54(10)	51(13)	69(12)	33(16)
Fellow U.S. soldiers	12(6)	11(8)	14(9)	9(9)
International soldiers	4(2)	4(3)	2(2)	15(10)
Other source	0	0	0	0
Don't know	<1(<1)	0	0	2(2)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used Flea or Tick Collars

	Total Population	Army	Marines/Navy	Air Force
Where worn, % (s.e.)				
Directly on the skin	21(8)	22 (11)	22(12)	8(6)
Over clothes or shoes	87(5)	92(5)	68(13)	90(7)
Some other way	7(3)	3(3)	24(11)	11(9)
Reasons for ceasing use, % (s.e.)				
Pests stopped being a problem	15(9)	19 (12)	2(2)	8(8)
Ran out of pesticides	11(9)	13 (12)	0	28(15)
Another reason	23(7)	17(9)	43(13)	27(18)
Side effects, % (s.e.)				
Reported experiencing side effects	5(3)	6(4)	5(4)	2(2)
Stopped using or reduced amount because of side effects	3(2)	5(3)	0	0

NOTE: Columns may sum to more than 100 percent because respondents could give multiple

answers.

Table 3.9
Tabulations for the Use of Other Personal Products by Self
(possible active ingredients include DEET, ethyl hexanediol)

Percentage (s.e.) Who Used Other Products

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
2(<1)	1(1)	1(<1)	4(1)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used Other Products[a]

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	Total GW Population (n = 7,440)		Army (n= 3,836)		Marines/Navy (n = 921)		Air Force (n = 2,683)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average	16(4)	1(<1)	13(6)	1(<1)	28(15)	2(1)	17(3)	2(<1)
Percentile								
5	2	1	1	1	2	1	2	1
25	5	1	2	1	6	1	5	1
50	12	1	5	1	15	1	12	1
75	20	2	60	2	88	4	20	2
95	88	4	60	2	120	6	60	3
100	120	6	60	2	120	6	120	4
Unknown	5	3	0	0	21	21	7	7

[a]The columns labeled "Times/day" indicate the number of times per day *for the days used.*

Source of Pesticides Among Those Who Used Other Products

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	87(9)	82(17)	68(22)	100
From PX	<1(<1)	0	3(3)	0
From United States	13(9)	18(17)	26(22)	0
Fellow U.S. soldiers	5(3)	0	21(18)	8(6)
International soldiers	<1(<1)	0	3(3)	0
Other source	0	0	0	0
Don't know	0	0	0	0

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used Other Products

	Total Population	Army	Marines/Navy	Air Force
Number of different powders used, # (s.e.)	1(<1)	1(<1)	1(<1)	1(<1)
Where used, % (s.e.)				
Body	64(13)	63 (23)	36(22)	74(10)
Uniform	8(4)	0	43(22)	8(5)
Body and uniform	28(13)	37 (23)	21(18)	19(9)
Reasons for ceasing use, % (s.e.)				
Pests stopped being a problem	7(4)	0	0	19(9)
Ran out of pesticides	12(6)	0	51(22)	16(8)
Another reason	43(14)	77 (15)	0	10(6)
Side effects, % (s.e.)				
Reported experiencing side effects	<1(<1)	0	0	1(1)
Stopped using or reduced amount because of side effects	0	0	0	0

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers or because of rounding.

- The estimated percentage of the population who used a particular form in total and by service;
- For those who used a particular form, the estimated average frequency of use, in terms of the average number of times per month and the average number of times per day, and the percentiles of use;
- For those who used a particular form, an estimated percentage breakdown of the source of pesticides;
- For those who used a particular form, the reasons they stopped using the pesticides;
- For those who used a particular form, the estimated percentage who reported experiencing side effects and the percentage who stopped or reduced using the pesticide because of side effects;
- The estimated average number of products used; and
- Where the products were used.

Tables 3.4 through 3.9 show that sprays were clearly the most common form of pesticide used. Sprays were used by almost half of Army personnel and more than one-third of the personnel in the other services. Those who used sprays used them about one and one-half times a day on average in the Army and Marine Corps/Navy and about once a day in the Air Force.[3] Personnel at the 95th percentile of those who used sprays applied them about six times a day, and the maximum reported use was 12 times a day[4] (slightly less in the Air Force).

Many personnel reported acquiring their sprays via "military issue," although they were also frequently acquired from other sources such as a military PX, via mail from friends and relatives, and from fellow U.S. soldiers. Two-thirds of the respondents using sprays reported applying them to both body and uniform, another third to just the uniform, and fewer to just the body.[5] About 10 percent of the population using sprays believed that they experienced side effects from a spray, and about one-half of these individuals stopped using the spray because of the perceived side effects.

Liquids and lotions (Tables 3.5 and 3.6) were the next most frequently reported forms. About one-quarter of Army and Marine Corps/Navy personnel reported their use. Use in the Air Force differed, with about 10 percent using liquids and about 20 percent using lotions. In all services, the average among those who used them was about thirty times per month, but about twice per day for both forms on the days they were used. The maximum use was about six times per day for the liquids and slightly higher for lotions.

Both forms were principally military issue, with most of the balance coming from fellow U.S. soldiers.[6] As might be expected, lotions were used mainly on the body, with a much smaller percentage of soldiers using them on both body and uniform. Liquids were used on the body by about one-half of the population, on the body and uniform by about one-third, and on only the uniform by about 5 percent of the population. As with the sprays, roughly 10 percent of the population perceived side effects from each of these forms, and about one-half of these stopped using the form because of the perceived side effects.[7]

Fewer than 10 percent of the population used personal powders,[8] as Table 3.7 shows. These personnel were largely Army, with only 1 to 2 percent of personnel in the other services using powders. Those who used powders used them on average about once per day; the 95th percentile for those who used powders was about three times per day, and the maximum reported use was five times per day. Compared to sprays, liquids, and lotions, powders were more likely to lead to perceived side effects, and more powder users stopped their use because of the perceived side effects.[9]

From Table 3.8, we find that about 3 percent of the population in the Army and Marine Corps/Navy and only about 1 percent in the Air Force used flea or tick collars. Among those who wore flea or tick collars, the median user wore the collar every day. Unlike the other forms of pesticides, most flea or tick collars were acquired either directly from the United States or from a military PX.[10] A large majority who used flea or tick collars wore them over clothes or shoes, although about 20 percent wore them directly on the skin.

The AFPMB issued a message specifying that flea or tick collars are not safe for human use (AFPMB, 1990). Although this message was transmitted in early December 1990, we found that personnel continued to wear these collars through the end of the survey period, July 1991.

Table 3.9 compiles the remaining "other" products reported, which comprise mainly various stick forms of pesticides. These were used by only a small fraction of the population, mostly in the Air Force.

Personal-Use Pesticide Tabulations by Active Ingredient

Tables 3.10 to 3.12 contain our best estimates of use by active ingredient (DEET, permethrin, and sulfur) for the in-theater Gulf War population. To make these estimates, we imputed the active ingredients from the limited information given in some responses. For responses that indicated multiple active ingredients, we estimated the probability of each candidate ingredient based on answers given by similar respondents who gave enough information to allow the ingredients to be identified. The probability of use for each ingredient was then used to apportion the sampling weights, and the statistics in the table were calculated from these values. Additional detail about the imputation and standard error calculations are provided in Appendix C. The tables list:

- The percentage of the population who used an active ingredient in total and by service; and
- Among those who used a product with the active ingredient, the average frequency of use, in terms of the average number of times per month and the average number of times per day, and the percentiles of usage.

Table 3.10
Tabulations for the Use of DEET by Self and Others
Percentage (s.e.) Who Used DEET

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
50(2)	54(3)	46(2)	38(2)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used DEET[a]

	Total GW Population (n = 235,962)		Army (n=165,584)		Marines/Navy (n = 44,069)		Air Force (n = 26,396)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average	47(2)	3(<1)	48(3)	3(<1)	49(4)	2(<1)	36(3)	2(<1)
Percentile								
5	4	1	4	1	4	1	3	1
25	12	1	12	1	12	1	8	1
50	30	2	30	2	30	2	21	2
75	60	3	68	3	60	4	60	3
95	167	7	180	7	180	8	120	6
100	480	16	450	16	480	16	450	10

NOTE: Forms included sprays, liquids, lotions, other.
[a]The columns labeled "Times/day" indicate the number of times per day *for the days used.*

Table 3.11

Tabulations for the Use of Permethrin for Personal Use by Self and Others
(forms included sprays, liquids)

Percentage (s.e.) Who Used Permethrin

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
6(1)	7(2)	5(1)	5(1)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used Permethrin

	Total GW Population (n = 30,032)		Army (n= 21,932)		Marines/Navy (n = 4,898)		Air Force (n = 3,357)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average	28(4)	2(<1)	30(5)	2(<1)	26(4)	2(<1)	14(2)	1(<1)
Percentile								
5	2	1	4	1	3	1	1	1
25	8	1	10	1	8	1	6	1
50	20	1	26	2	24	1	10	1
75	48	2	60	2	48	2	30	1
95	120	4	120	5	120	5	60	3
100	420	14	420	14	360	12	93	4

NOTE: The columns labeled "Times/day" indicate the number of times per day *for the days used.*

Table 3.12
Tabulations for the Use of Sulfur (Benzocaine) for Personal Use by Self and Others

Percentage (s.e.) of Population That Used Benzocaine

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
3(1)	4(1)	2(1)	1(1)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used Benzocaine[a]

	Total GW Population (n = 15,437)		Army (n=12,749)		Marines/Navy (n = 2,047)		Air Force (n = 827)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average	35(5)	2(<1)	35(6)	2(<1)	39(7)	2(<1)	23(6)	2(<1)
Percentile								
5	2	1	2	1	2	1	2	1
25	8	1	8	1	8	1	5	1
50	15	1	15	1	20	1	12	1
75	30	2	60	2	30	2	30	2
95	90	3	91	4	74	3	60	3
100	260	10	260	10	134	6	90	6

NOTE: Forms included sprays, liquids, lotions.

[a]The columns labeled "Times/day" indicate the number of times per day *for the days used.*

We find that DEET was the most common personal pesticide active ingredient (see Table 3.10). DEET was used by half of the Army and Marine Corps/Navy population and slightly more than a third of the Air Force population.[11] Among those who used DEET, on average it was used about three times a day for 15 days a month in the Army, and twice a day in the Marine Corps/Navy and Air Force for similar periods. The 95th percentile for frequency of use among those who used DEET was about seven times a day, although the maximum was 16 times a day (for the Army and Marine Corps/Navy; slightly less for the Air Force).

As shown in Table 3.11, permethrin was used by about 6 percent of the ODS/DS population, with a slightly higher percentage in the Army, and a slightly lower percentage in the other services.[12] Frequency of use among those who used permethrin averaged almost 30 times a month, although it tended to be used twice a day for two weeks out of four. The 95th percentile for frequency for those who used permethrin was four times a day, although the maximum was 14 times a day for the Army; it was slightly less for the Marine Corps/Navy, and for the Air Force the maximum was only four times per day.[13]

As Table 3.12 shows, sulfur was used by about 3 percent of the population--slightly higher in the Army and slightly lower in the Marine Corps/Navy and Air Force. Among those who used them, sulfur products were used on average slightly more than 30 times a month, except in the Air Force where they were used only 20 times a month. When sulfur was used, it was used about twice a day on average. At the 95th percentile, it was used about three times a day, although the maximum daily usage was ten times a day in the Army and six times a day in the Marine Corps/Navy and Air Force.

FIELD-USE PESTICIDE TABULATIONS BY FORM

In general, we were not able to classify field-use pesticides by specific active ingredients because the information provided by respondents was too sparse. For example, very few respondents could actually name the field pesticide they reported. Among those who could not provide a name, most could not provide much, if any, specific identifying information, such as color or smell. Because of this, we tabulated field-use pesticides only by form.

We expected that field-use pesticides would be both underreported and reported with sparse information because, unlike the personal-use pesticides, field-use pesticides were generally not applied by the survey respondent. Thus, the respondent could generally provide information only on observed applications, which is most likely a subset of all the applications that occurred.

Tables 3.13 through 3.19 contain our best estimates of use from the survey data for the entire in-theater Gulf War population. The tables list, for those who used or observed the use of a particular field pesticide form:

- The estimated percentage for the total population and by service;
- For those who used a particular form, the estimated average frequency of use in terms of the average number of times per month, and the percentiles of use for number of times per month;
- An estimated percentage breakdown of the source of pesticides;
- The reasons they stopped using the pesticide(s);
- The percentage who reported experiencing side effects; for those who experienced side effects, the percentage who stopped or reduced use of the pesticide;
- The average number of products used or observed; and
- Where the products were used or observed to be used.

Table 3.13

Tabulations for the Field Use of Aerosols by Self and Others
(possible active ingredients include allethrin, permethrin, resmethrin, chlorpyrifos, DEET, malathion, phenothrin, propoxur)

Percentage (s.e.) Who Used or Observed the Use of Aerosols

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
28(2)	31(2)	20(2)	27(2)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used or Observed the Use of Aerosols

	Total GW Population (n = 13,291)		Army (n= 95,610)		Marines/Navy (n = 19,133)	Air Force (n = 18,586)
	Times/mo	Times/mo	Times/mo	Times/mo		
Average	40(3)	43(3)	44(7)	25(2)		
Percentile						
5	2	3	2	1		

25	8	12	6	4
50	30	30	30	16
75	60	60	60	40
95	120	120	118	90
100	533	240	533	210
Unknown	5	5	6	5

Source of Pesticides Among Those Who Used or Observed the Use of Aerosols

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	68(4)	69(5)	61(7)	71(5)
From PX	22(4)	22(5)	30(7)	16(4)
From United States	11(3)	12(4)	14(5)	7(3)
Fellow U.S. soldiers	12(3)	10(4)	25(7)	13(4)
International soldiers	11(3)	11(4)	13(5)	9(3)
Other source	1(1)	1(1)	0	1(1)
Don't know	1(<1)	1(<1)	1(1)	2(2)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used or Observed the Use of Aerosols

	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Where used				
Sleeping area	84(2)	86(3)	82(4)	72(4)
Eating area	47(3)	49(4)	46(5)	37(4)
Working area	63(3)	59(4)	72(4)	71(4)
Latrine	57(3)	62(4)	54(5)	36(4)
Other area	49(3)	51(4)	51(5)	39(4)
Who used aerosols				
U.S. military troops	97(1)	97(1)	96(2)	98(1)
International soldiers	3(1)	2(1)	3(2)	6(2)
Local source	7(2)	9(2)	3(2)	5(2)
Other	1(<1)	<1(<1)	0	2(1)
Side effects				
Reported experiencing side effects from own aerosols	10(3)	11(4)	8(4)	7(3)
Stopped using or reduced amount because of side	7(2)	7(3)	5(3)	3(2)

effects	7(2)	7(3)	3(3)	3(2)
Reported experiencing side effects from others' aerosols	6(2)	6(2)	9(3)	3(1)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Table 3.14

Tabulations for the Field Use of Other Sprays by Self and Others
Percentage (s.e.) of Those Who Used or Observed the Use of Other Sprays

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
20(1)	15(2)	23(2)	36(2)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used or Observed the Use of Other Sprays

	Total GW Population (n = 92,083)		Army (n= 45,634)		Marines/Navy (n = 21,826)	Air Force (n = 24,623)
	Times/mo	Times/mo	Times/mo	Times/mo		
Average	11(1)	14(2)	8(1)	9(1)		
Percentile						
5	1	1	1	1		
25	2	2	2	2		
50	4	4	4	4		
75	8	13	7	8		
95	30	42	30	30		
100	90	90	64	90		
Unknown	6	6	5	6		

Source of Pesticides Among the Those Who Used or Observed the Use of Other Sprays

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	77(14)	79(16)	71(24)	43(35)
From PX	0	0	0	0
From United States	0	0	0	0
Fellow U.S. soldiers	21(14)	18(16)	29(24)	57(35)
International soldiers	1(1)	0	0	43(35)
Other source	0	0	0	0
Don't know	6(5)	3(3)	26(22)	0

Details of Use Among Those Who Used or Observed the Use of Other Sprays

	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Where used				
Over the camp	68(14)	94(7)	42(17)	100
Around the camp	92(2)	90(5)	96(2)	91(2)
Sleeping, eating, or working areas	94(2)	96(2)	90(5)	91(4)
Other area	84(4)	88(6)	76(7)	79(5)
Who used aerosols				
U.S. military troops	52(3)	54(6)	54(5)	47(4)
International soldiers	5(1)	5(3)	3(2)	7(2)
Local source	34(3)	36(6)	30(4)	36(3)
Other	3(1)	2(1)	5(2)	4(2)
Side effects				
Reported experiencing side effects from own sprays	22(14)	26(17)	0	0
Stopped using or reduced amount because of side effects	15(14)	18(16)	0	0
Reported experiencing side effects from others' sprays	16(3)	19(5)	16(3)	12(2)

NOTES: Columns may sum to more than 100 percent because respondents could give multiple answers.

Table 3.15
Tabulations for the Field Use of Pellets, Crystals, and Granules by Self and Others
(possible active ingredients include azamethiphos, brodifacoum, bromadiolon, chlorpyrifos, methomyl, pyrethrum)

Percentage (s.e.) Who Used or Observed the Use of Pellets, Crystals, and Granules

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
12(1)	12(2)	10(1)	11(1)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used or Observed the Use of Pellets, Crystals, and Granules

	Total GW Population (n = 54,548)		Army (n= 37,623)		Marines/Navy (n = 9,134)	Air Force (n = 7,791)
	Times/mo	Times/mo	Times/mo	Times/mo		
Average	24(2)	24(2)	28(3)	22(2)		
Percentile						
5	1	1	2	1		
25	5	6	8	4		
50	30	30	30	16		
75	30	30	31	30		
95	60	60	60	60		
100	90	90	90	74		
Unknown	5	5	5	5		

Source of Pesticides Among Those Who Used or Observed the Use of Pellets, Crystals,and Granules

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	75(8)	76(11)	75(12)	18(15)
From PX	0	0	0	0
From United States	1(1)	0	0	16(15)
Fellow U.S. soldiers	9(6)	8(8)	17(10)	0
International soldiers	9(4)	9(5)	0	35(16)
Other source	1(1)	0	7(7)	0
Don't know	3(2)	1(1)	10(10)	2(2)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used or Observed the Use of Pellets, Crystals, and Granules

	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Where used				
Sleeping area	60(5)	57(7)	66(7)	64(6)
Eating area	42(5)	40(7)	52(7)	45(6)
Working area	59(5)	56(7)	69(7)	58(6)
Latrine	52(5)	49(7)	62(7)	57(6)
Other area	29(4)	23(5)	45(7)	39(6)
Who used				

U.S. military troops	86(3)	86(5)	92(4)	78(5)
International soldiers	3(1)	2(1)	4(3)	12(4)
Local source	11(3)	10(4)	3(3)	26(6)
Other	2(2)	3(3)	0	2(2)
Side effects				
Reported experiencing side effects from own pellets, etc.	5(3)	6(4)	2(2)	1(1)
Stopped using or reduced amount because of side effects	1(1)	2(2)	0	0
Reported experiencing side effects from others' pellets, etc.	3(2)	3(2)	3(2)	2(2)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers

Table 3.16

Tabulations for the Field Use of Powders by Self and Others
(possible active ingredients include lindane, carbaryl dust, diazinon dust)[a]

Percentage (s.e.) Who Used or Observed the Use of Field Powders

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
13(1)	15(2)	12(1)	8(1)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used or Observed the Use of Powders

	Total GW Population (n = 62,150)		Army (n= 45,246)		Marines/Navy (n = 11,746)	Air Force (n = 5,147)
	Times/mo	Times/mo	Times/mo	Times/mo		
Average	22(2)	23(3)	24(3)	15(2)		
Percentile						
5	2	2	2	2		
25	4	8	7	4		
50	16	30	14	8		
75	30	30	30	30		
95	60	60	60	60		
100	156	156	90	60		
Unknown	8	10	4	1		

Source of Pesticides Among Those Who Used or Observed the Use of Powders

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	81(8)	83(10)	82(9)	58(16)
From PX	3(2)	0	7(6)	21(14)
From United States	14(7)	17(10)	10(8)	6(6)
Fellow U.S. soldiers	4(3)	4(4)	6(6)	0
International soldiers	9(5)	10(8)	2(2)	27(14)
Other source	0	0	0	0
Don't know	0	0	0	0

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used or Observed the Use of Powders

	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Where used				
Sleeping area	74(4)	76(5)	68(6)	73(7)
Eating area	41(5)	40(6)	50(6)	36(7)
Working area	49(5)	48(6)	61(6)	40(7)
Latrine	64(5)	66(6)	58(6)	55(7)
Other area	40(5)	39(6)	40(6)	46(8)
Who used				
U.S. military troops	88(3)	90(4)	83(5)	77(7)
International soldiers	5(2)	5(3)	4(3)	8(4)
Local source	9(3)	8(3)	6(3)	24(7)
Other	1(<1)	<1(<1)	2(2)	1(1)
Side effects				
Reported experiencing side effects from own powders	6(3)	6(3)	7(6)	0
Stopped using or reduced amount because of side effects	1(1)	2(2)	0	0
Reported experiencing side effects from others' powders	5(2)	5(3)	6(3)	2(2)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers

[a]Lime was also used to control pests. However, since it is not a pesticide, we removed it from these tabulations whenever we could identify it.

Table 3.17
Tabulations for the Field Use of Liquids by Self and Others
(possible active ingredients include azamethiphos, bendiocarb, diazinon,

propuxor, pyrethrum, pentachlorophenol, cypermethrin)

Percentage (s.e.) Who Used or Observed the Use of Field Liquids

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
4(1)	4(1)	5(1)	1(<1)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used or Observed the Use of Liquids

	Total GW Population (n = 18,242)		Army (n= 13,207)		Marines/Navy (n = 4,337)	Air Force (n = 698)
	Times/mo	Times/mo	Times/mo	Times/mo		
Average	27(4)	23(4)	41(10)	18(11)		
Percentile						
5	1	1	1	1		
25	4	8	4	1		
50	21	27	24	5		
75	30	30	30	30		
95	60	60	60	90		
100	150	120	150	90		
Unknown	1	0	4	0		

Source of Pesticides Among Those Who Used or Observed the Use of Liquids

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	90(6)	96(5)	83(11)	100
From PX	8(5)	0	16(10)	81(21)
From United States	0	0	0	0
Fellow U.S. soldiers	9(5)	0	20(11)	81(21)
International soldiers	3(3)	4(5)	0	0
Other source	0	0	0	0
Don't know	0	0	0	0

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used or Observed the Use of Liquids

	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Where used				
Sleeping area	72(8)	73(10)	74(9)	52(18)
Eating area	42(9)	36(11)	60(10)	31(16)
Working area	55(9)	50(12)	65(10)	78(13)
Latrine	50(9)	51(12)	45(11)	58(18)
Other area	50(9)	43(12)	71(9)	36(16)
Who used				
U.S. military troops	86(4)	93(4)	75(10)	33(15)
International soldiers	7(3)	7(4)	4(4)	36(19)
Local source	9(3)	5(3)	14(8)	39(18)
Other	2(1)	0	5(5)	9(9)
Side effects				
Reported experiencing side effects from own liquids	2(2)	3(3)	0	19(21)
Stopped using or reduced amount because of side effects	0	0	0	0
Reported experiencing side effects from others' liquids	16(8)	18(11)	14(8)	0

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers

Table 3.18
Tabulations for the Use of No-Pest Strips by Self and Others
(possible active ingredients include dichlorvos)

Percentage (s.e.) Who Used or Observed the Use of No-Pest Strips

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
7(1)	7(1)	5(1)	6(1)

Percentage (s.e.) Reporting on Density[a] of No-Pest Strips Among Those Who Used Them or Observed Their Use

	Total GW Population (n = 30,530)				Army (n = 21,912)				Marines/Navy (n = 4,604)				Air Force (n = 4,014)			
	<1	~1	>1	?	<1	~1	>1	?	<1	~1	>1	?	<1	~1	>1	?
1	45 (7)	13 (4)	5(2)	37(6)	51(9)	15(6)	4(2)	31(8)	29 (9)	6(4)	12(6)	53 (10)	30(8)	12 (6)	6(3)	52 (9)
2	13 (4)	16 (5)	8(2)	63(6)	13(5)	20(7)	4(2)	62(8)	11 (6)	2(2)	19(8)	69(9)	18(6)	9(6)	13 (6)	61 (8)
3	46 (9)	26 (8)	27 (8)	<1 (<1)	49 (13)	26 (10)	25 (11)	0	11 (5)	40 (13)	49 (13)	0	78 (10)	7(7)	8(6)	7(7)
4	19 (8)	1(1)	1(1)	79(8)	22 (11)	1(1)	0	77 (11)	12 (9)	3(3)	0	85 (10)	12(5)	1(1)	6(6)	82 (7)
5	6(2)	11 (3)	30 (6)	53(6)	5(2)	10(4)	30(8)	55(8)	3(3)	19(8)	27(9)	51 (10)	18(7)	8(4)	28 (8)	46 (9)
6	2(1)	9(4)	2(1)	87(4)	1(1)	12(6)	0	87(6)	1(1)	0	11(7)	89(7)	9(5)	7(5)	4(4)	80 (7)

NOTES The numbers in the first column identify the location used. 1 = sleeping quarters; 2 = mess halls and other designated eating areas; 3 = other eating areas; 4 = work area; 5 = latrine; 6 = other. Column headings identify the density. <1 = less than 1 per 10 x 10 feet; ~1 = about 1 per 10 x 10 feet; > 1 = more than 1 per 10 x 10 feet; ? = don't know.

[a]Density is calculated as 10 ft by 10 ft of space.

Source of Pesticides Among Those Who Used or Observed the Use of No-Pest Strips

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	46(6)	49(9)	24(8)	55(9)
From PX	14(5)	14(6)	12(6)	15(6)
From United States	13(5)	15(7)	9(4)	10(5)
Fellow U.S. soldiers	11(5)	12(6)	3(2)	12(6)
International soldiers	8(3)	8(4)	5(3)	12(6)
Other source	<1(<1)	0	0	3(3)
Don't know	34(6)	30(7)	56(10)	24(7)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used or Observed the Use of No-Pest Strips

	Total Population	Army	Marines/Navy	Air Force
Number of No-Pest strips used, # (s.e.)	1(<1)	1(<1)	1(<1)	1.5(<1)
Where used, % (s.e.)				
Sleeping area	64(6)	70(8)	48(10)	51(9)
Eating area	68(9)	68(14)	84(10)	61(9)
Working area	50(6)	49(9)	49(10)	62(8)
Vehicle	19(5)	22(7)	20(7)	7(5)
Latrine	47(6)	45(8)	49(10)	54(9)
Other area	14(4)	13(6)	11(7)	20(7)
Where used in vehicle, % (s.e.)				
Enclosed space	7(3)	5(3)	20(7)	3(3)
Open space	12(5)	16(7)	0	4(4)
Don't know	81(5)	78(7)	81(7)	93(5)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers or because of rounding.

Table 3.19
Tabulations for the Field Use of Other Pesticides by Self and Others
(possible active ingredients include TBD)

Percentage (s.e.) Who Used or Observed the Use of Other Pesticides

Total Population (n = 469,047)	Army (n = 305,002)	Marines/Navy (n = 94,984)	Air Force (n = 69,061)
3(1)	3(1)	3(1)	3(1)

Average Frequency of Use (s.e.) and Percentiles for Frequency of Use Among Those Who Used or Observed the Use of Other Field Pesticides

	Total GW Population (n = 12,872)		Army (n= 7.995)		Marines/Navy (n = 3,119)	Air Force (n = 1,757)
	Times/mo	Times/mo	Times/mo	Times/mo		
Average	28(4)	26(5)	28(7)	37(9)		
Percentile						
5	2	2	2	1		
25	8	8	5	12		
50	30	30	22	30		
75	60	30	60	54		
95	90	90	90	180		
100	180	90	90	180		

Unknown	11	11	12	12

Source of Pesticides Among Those Who Used or Observed the Use of Other Pesticides

Source	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Military issue	58(13)	68(19)	57(20)	19(15)
From PX	5(4)	0	0	37(22)
From United States	15(7)	4(5)	23(15)	41(23)
Fellow U.S. soldiers	23(12)	21(18)	18(15)	44(23)
International soldiers	9(5)	7(7)	4(4)	32(20)
Other source	1(1)	0	2(2)	0
Don't know	4(4)	0	0	29(23)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers.

Details of Use Among Those Who Used or Observed the Use of Other Pesticides

	Total Population % (s.e.)	Army % (s.e.)	Marines/Navy % (s.e.)	Air Force % (s.e.)
Where used				
Sleeping area	58(9)	58(13)	61(13)	54(13)
Eating area	30(8)	30(11)	37(12)	17(9)
Working area	33(9)	30(13)	41(13)	33(12)
Latrine	25(7)	24(11)	30(12)	20(10)
Other area	36(9)	35(13)	31(12)	45(13)
Who used				
U.S. military troops	96(2)	99(1)	100	77(12)
International soldiers	5(3)	4(4)	9(8)	4(4)
Local source	6(3)	4(3)	10(8)	11(10)
Other	0	0	0	0
Side effects				
Reported experiencing side effects from own pesticides	25(15)	33(24)	23(18)	0
Stopped using or reduced amount because of side effects	0	0	0	0
Reported experiencing side effects from others' pesticides	4(2)	0	8(8)	14(10)

NOTE: Columns may sum to more than 100 percent because respondents could give multiple answers

The most frequently used or observed field pesticides were aerosols; Table 3.13 shows that slightly less than one-third in each service reported using aerosols in the field. Whereas a smaller percentage of the population used or observed aerosols, those who reported them indicated heavier use in the sleeping, eating, working, and other areas. "Other" sprays in Table 3.14 were similarly ubiquitous and used or observed by about 20 percent of the population. This is the only form in which the fraction of Air Force personnel using or observing the form is significantly higher than in the other services. "Other" sprays were sprays applied by a hand-held sprayer, a truck sprayer, or a plane sprayer.

Of those who saw or used sprayers, we estimate that 40 percent were hand-held sprayers (by service: 47 percent in the Army, 36 percent in the Marine Corps/

Navy, and 29 percent in the Air Force), 69 percent were truck sprayers (by service: 60 percent in the Army, 71 percent in the Marine Corps/Navy, and 81 percent in the Air Force), and 4 percent were plane sprayers (by service: 4 percent in the Army, 10 percent in the Marine Corps/Navy, and 1 percent in the Air Force).[14] The percentages sum to more than 100 because respondents could give answers for up to three sprayers.

Tables 3.15 and 3.16 show that slightly more than 10 percent of the population used or observed pellets, crystals, granules, and field powders, respectively. Field liquids were used or observed by about 4 percent of the population (Table 3.17). On average, among those who reported them, these forms were used or observed about 20 times per month, with the 95th percentile at about 60 times per month. All of these forms were predominantly military issue, used by U.S. military troops, and observed or used roughly equally in all areas.

Table 3.18 demonstrates that about 7 percent of the population used or observed No-Pest strips. It also shows that in most of the locations (sleeping, eating, work, latrine, and "other"), the density of No-Pest strips was less than or about equal to the recommended density of one per 100 square feet of floor area.[15] However, 30 percent of latrines and other eating areas (non-mess hall and other areas not designated specifically for eating) exceeded this standard. Other eating areas had an average density of about two per 100 square feet and latrines had an average density of about four per 100 square feet.

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[1]The in-theater Gulf War population consists of all Army and Marine Corps personnel located in Saudi Arabia, Kuwait, Bahrain; all Air Force personnel located in Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, and Oman; and Navy personnel in units that can be identified as being ashore in Saudi Arabia, Kuwait, and Bahrain. Details of the statistical methodology are contained in Appendix C.

[2]Fleas were actually very unlikely in this region. While service members often referred to "sand fleas," there is no such species. The pests were probably phlebotomine sand flies, which are so small they could have been confused with fleas when they bite.

[3]Frequency of use is the combined frequency from all sprays reported.

[4]A 95th percentile for frequency of use at six times a day means that 5 percent of the population applied sprays at least six times a day.

[5]The only personal-use spray available in the military supply system during ODS/DS was a permethrin product intended for use on uniforms only. Thus, sprays acquired as "military issue" and used on the body represent either a recall error on the part of the respondent, a definition of "military issue" more liberal than just the "military supply system," or a misuse of the pesticide. See Chapter Five on possible misuse of pesticides.

[6]Gambel et al. (1998) found that more than 60 percent of the soldiers used commercial repellents. Our results show a much higher use of military issue products. This differential may be due to a restricted availability of commercial products during ODS/DS, recall error, perhaps the use of the response "military issue" to mean more than just the military supply system, or some combination of all of these and other factors.

[7]The survey did not solicit specific details about side effects.

[8]Survey respondents did report powders that did not contain pesticides, such as talcum powder. Data on these nonpesticides were removed as much as possible.

[9] The survey did not solicit specific details about side effects.

[10]Despite the fact that 6 percent of the population indicated that their flea collars were military issue, these products are not now, nor have they ever been, available through the military supply system. This may reflect respondents' perception of military issue as encompassing more than the military supply system. For example, one respondent stated, "flea collars [were] used by [the] whole unit (22 people) and these collars were U.S. military issued."

[11]These results are consistent with reports on the use of insect repellents by Army personnel in surveys conducted by Gambel et al. (1998). Gambel et al. found that 56.5 percent of the personnel they surveyed who were deployed in Bosnia applied insect repellents to the skin. However, our results show higher use than Gambel et al. found from their survey of about 200 Army personnel deployed to Kuwait in 1994 during Operation Vigilant Warrior, where only 26.2 percent of the personnel said they used insect repellents on the skin. Yet, in a similar survey of soldiers deployed to Haiti, they found that 94.3 percent of the personnel used insect repellents on their skin.

[12]These results are also consistent with those of Gambel et al. (1998). In their surveys, they found that only 7.6 percent of troops deploying to Kuwait in 1994, Haiti in 1995, and Bosnia in 1996 treated their uniforms before deployment. They found that only 13.1 percent treated their uniforms while in Kuwait, 29.4 percent while in Haiti, and 18.9 percent while in Bosnia.

[13]The only permethrin product available from the military supply system at the time of ODS/DS was an aerosol for treating uniforms. With proper application, that product should have lasted in a uniform for about six weeks or six launderings. Thus, the average level of reported use was well in excess of the recommended amount. This result may indicate misclassification or misuse (or both) of the pesticide. See Chapter Five on possible misuse of pesticides.

[14]Despite respondents' perceptions that aerial application of pesticides occurred, no known applications were made by any of the services during the Gulf War.

[15]The recommended density is one per 1,000 cubic feet, which the survey simplified by assuming a

fixed ten-foot ceiling height, in which case the recommended density reduces to one per 100 square feet of floor space..

Chapter Five: Potential Misuse or Overuse of Pesticides

It is difficult to evaluate whether pesticides were used properly, given the nature of the survey data. This is because the data primarily describe frequency of use by form of pesticide. Without data on color and smell, in general, it is not possible to link any given form to a specific active ingredient. An additional difficulty is the accuracy of self-reported data. Thus, we can report only what respondents told us; we often cannot determine whether a potential misuse is simply a case of misidentification or actual misuse.

In spite of such difficulties, in this chapter we highlight those identifiable cases in which pesticide use is questionable (either in terms of potential overuse or misuse). Most of these results are based only on those pesticides that were specifically named by respondents. Although such an analysis does not lend itself to statistical generalizations for the population, it does serve to indicate areas possibly deserving additional study.

POSSIBLE MISUSE OR OVERUSE

Personal Pesticides

Permethrin. Permethrin is a synthetic pyrethroid that acts as a contact repellent against mosquitoes, biting flies, and crawling arthropods such as ticks and chigger mites. Permethrin binds so strongly to fabric that treated uniforms will continue to provide protection after several washings. The recommended use of permethrin 0.5 percent was for bed netting and uniforms (except the uniform cap, underwear, and T-shirts). Directions for use state to spray the clothing from a distance of six to eight inches away, for at least 30 seconds on each side and allow to dry for two to four hours according to ambient humidity and to reapply after six weeks and its sixth laundering.[1] However, the literature indicates that when used in conventional doses, permethrin is safe even when applied to the skin in small doses (Cecchine et al. forthcoming).

In Chapter Three, we assumed that the pesticides were appropriately used--that sprays used on the body were DEET. However, almost 31 percent of the personnel (n = 143,394) indicated using a military-issue spray. If these military-issue sprays were instead all classified as permethrin, since the only spray available from the military supply system was permethrin-based, then we would estimate that (1) 1.5 percent of the population would have sprayed permethrin on their bodies (n = 7,024), and (2) another 20 percent would have sprayed it on some combination of body and uniform (n = 94,923).

Among the respondents who provided pesticide names, we observed five individuals (3 Army, 1, Marine Corps, and 1 Air Force, representing 1,600 individuals in the population) who named permethrin and said they used it on their bodies, and another 10 who said they used it on their body and uniform. Frequency of use varied from every other day to four times a day over the 30-day period surveyed. While the interpretation of "military issue" as meaning from the military supply system is too strict, these two estimates provide bounds on the likely bodily application of permethrin: from less than 1 percent to about 20 percent of the population. Based on the survey results of Gambel et al. (1998), we expect that the actual number is closer to the lower bound.[2]

d-Phenothrin. d-phenothrin, like permethrin, is a synthetic pyrethroid insecticide. The literature indicates that when used in conventional doses, d-phenothrin, like permethrin, is safe even when applied to the skin in small doses (Cecchine et al, forthcoming). Directions for use on aircraft are to

spray for ten seconds per 1,000 cubic feet in a sweeping motion and to stop ventilation for at least three minutes after spraying. Directions for use indoors (in buildings, vans, ships, or tents) are to spray for ten seconds per 1,000 cubic feet in a sweeping motion three feet away from surfaces and to close the treated area for at least 30 minutes after spraying and to ventilate before re-entry.[3] Instructions on the label say that d-phenothrin should not be used on skin or clothing. However, among the respondents who provided pesticide names, three individuals indicated that they used d-phenothrin as a personal pesticide (representing 1,292 personnel in the population); two of the three indicated they used it on their uniforms, and one on uniform and body. Frequency of use ranged from 60 times in 30 days to four times in 30 days.

Lindane. Lindane, an organochloride pesticide, was used as a field pesticide in the delousing of prisoners of war. However, many U.S. soldiers were also issued small containers of lindane for personal use. Directions for use indicate that personnel should use no more than one can of two ounces per week for up to two weeks for head and body lice.[4] In the survey data, 11 people (representing 4,072 people in the total population) reported using powders with colors and smells consistent with lindane (see Table C.3). Of these, five people indicated that they used the powder from one to three times each day, every day, for the 30-day period surveyed; another three indicated that they used it daily for one to three weeks; and three used it fewer than five times in a month.

Field-Use Pesticides for Personal Use

Parathion. Parathion, an organophosphate, is a highly toxic insecticide.[5] Parathion may be purchased and used only by certified applicators. It is used to control boll weevils and many biting or sucking insect pests of agricultural crops, primarily cotton. It kills insects by contact, or through ingestion and respiration. One respondent reported using parathion in a spray form on his uniform every day; however, we suspect that the respondent likely meant permethrin.

DDT. Four respondents, representing 1,367 people in the population, reported using DDT. Two reported it in spray form and two in liquid in frequencies that ranged from eight to 20 times in 30 days. Although DDT was held in war reserve stocks by the DoD until July 1992, no DDT was issued during the Gulf War. It is most likely that the respondents mistakenly identified DEET as DDT.

Other Pesticide Use

Flea Collars. Table 3.9 shows that approximately 3 percent of Army and Marine Corps/Navy personnel and about 1 percent of Air Force personnel used animal flea and tick collars. Flea and tick collars contain organophosphates, carbamates, pyrethroids, and organochloride pesticides that may have adverse dermal or systemic effects. Their safety has not been tested for human use.[6] Almost 50 percent of the respondents who wore the collars wore them for the entire 30-day period they were questioned about. The majority of them wore the collars over their clothes or shoes.

No-Pest Strips. Table 3.18 shows that about 7 percent of the in-theater Gulf War personnel used or observed the use of No-Pest strips. No-Pest strip insecticide has dichlorvos, an organophosphate, as the active ingredient (Cecchine et al., forthcoming). Between 5 and 8 percent of the personnel who reported using No-Pest strips indicated that they were hung in densities higher than one per 1,000 cubic feet, the maximum recommended by the manufacturer.[7]

MULTIPLE PESTICIDE USE

We found that personnel who reported a high frequency of use with one pesticide form would have been more likely to use (or report) high frequencies for multiple forms and thus might be exposed to a "cocktail" of pesticides. For both personal-use and field-use pesticides, we found that the number of people reporting multiple uses over the 95th percentile is greater than what would be expected by chance alone. This conclusion continues to hold even when the services are considered separately--personnel reporting high frequency of use or observed use of one form are more likely to report high use of another form.

We also found that those who report frequent use of personal pesticides tend to report frequent use of field pesticides. Seasonality and geography are likely to explain some or all of these associations. However, they could also be at least partially explained if some respondents had a tendency to either experience or report high use in general.

We examined the 12 people who had three or four high frequencies of use (above the 95th percentile) of personal pesticides and found them demographically similar in only one respect: eleven of the 12 were either retired or civilian. Otherwise, they were from all the services, of a variety of ranks and races and shared other demographic characteristics. Of the 12, 11 frequently used personal sprays, nine frequently used personal liquids, nine used lotions, four powders, and three flea or tick collars.

We also examined the 25 people who had three or four high frequencies of use of field pesticides. The distribution across services was as expected, with the Air Force having the fewest personnel (four), followed by the Marine Corps/Navy (eight), and then the Army with the largest number (13). Of the 25 respondents, 20 reported high frequency of use of field powders, 14 of aerosols, 12 of "other" spraying, 11 of field liquids, and ten of pellets, granules, and crystals. Within this group, active duty, reserve, retired, and civilian personnel were all roughly equally represented. Other demographics within the Marine Corps/Navy personnel reflected the larger respondent population. The same is true for Air Force personnel, except that three of the four were senior enlisted.

The Army personnel demographics, on the other hand, were somewhat unusual. Of the 13 Army personnel, ten were African-American and seven were senior enlisted. (Not all the senior enlisted were African-American, however.) It is unlikely that this could happen by chance.[8] The unusually high number of senior enlisted personnel for both the Army and the Air Force supports our initial hypothesis that senior personnel would have additional knowledge and information about the use of field pesticides. The high number of Army African-American personnel is consistent with the results in Tables 4.8 and 4.10, although we do not have a satisfactory explanation for it.

We also examined the effect of removing the 12 personal-use and 25 field-use "high use" personnel from the models for Tables 4.7 through 4.10. We found that removing them has no practical effect on the results.

PB PILLS

We estimate from the survey data that slightly more than half of the in-theater Army and Marine Corps/Navy personnel took PB pills, as shown in Table 5.1, whereas only about one-quarter of the Air Force took them. Of those who took PB pills, our data indicate that on average the personnel in all services took about one pill per day.

Table 5.1

Estimated Fraction of the In-Theater Gulf War Population Who Took PB Pills

Use of PB Pills	Total	Army	Marines/Navy	Air Force
Percent of population (s.e.)	48(2)	52(2)	51(2)	23(2)
Estimated number of personnel (out of 469,047 personnel on the ground in theater)	223,501	158,889	48,599	16,012

Although the Air Force is clearly different in terms of the fraction of personnel who took PB pills, among those who took them there is no statistical difference between the services for the average number of pills taken in a 30-day period. As Table 5.2 shows, however, among the personnel who took PB pills, the quantity taken varied significantly. Median use was 20 pills in a 30-day period--or about two per day for ten days--across all the services. The maximum reported usage was *nine* pills a day, or 224 in a month.

Table 5.2

Average Frequency of Use and Percentiles for Frequency of Use Among Those Who Took PB Pills

	Total GW Population (n = 223,501)		Army (n=158,889)		Marines/Navy (n = 48,599)		Air Force (n = 16,012)	
	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day	Times/mo	Times/day
Average (s.e.)[a]	26(1)	1.7(<1)	26(2)	1.7(<1)	27(2)	1.7(<1)	28(2)	1.9(<1)
Percentile								
50	20	2	20	2	20	1	20	2
75	31	2	31	2	31	2	42	3
95	84	3	63	3	84	3	93	3
100	114	9	217	9	224	8	93	6

NOTE: The columns labeled "Times/day" indicate the number of times per day *for the days used.*
[a]"s.e." stands for "standard error," a commonly used statistical measure of the variability of the average.

Most of the personnel who used PB pills reported taking three or fewer per day for fewer than 30 days out of the month they reported, but some respondents reported taking a large number of pills for most of the month. As Table 5.3 shows, 21 respondents, or about 1 percent of the sample, indicated that they had taken four or more pills per day. At the most extreme, one or more individuals reported taking four, five, seven, and eight pills a day for 30 days, which means they took the pills at that level of dosage for the entire month we asked them about.

Table 5.3
Daily Frequency of Use and Number of Days Used in the Month Surveyed Among Those Who

Took Three or More PB Pills per Day

Army		Marine Corps		Air Force		Navy	
Per Day	Days Taken	Per Day	Days Taken	Per Day	Days Taken	Per Day	Days Taken
4	6	4	2	4	3	None with four or more per day	
4	14	4	5	4	21		
5	31	4	7	5	2		
6	2	4	15	6	3		
7	31	4	30				
8	7	4	31				
9	21	5	15				
		5	30				
		6	7				
		8	28				

In a logistic regression model,[9] we find that the odds of taking PB pills in the winter are twice the odds of taking them in the summer ($p = 0.001$)--a result likely attributable to the events during that point in the war and not to the season--and the odds of males taking PB pills are three times those of females ($p = 0.001$).[10] Also, the odds of African-American personnel taking PB pills are twice those of Caucasians ($p = <0.001$), and personnel in the desert had twice the odds of taking PB pills of personnel in tent cities ($p = 0.002$), who in turn had twice the odds of personnel in buildings ($p = 0.009$).

Those who took the pills, however, took 66 percent more pills in the summer ($p = 0.003$), females took almost 140 percent more ($p = 0.01$), and senior enlisted took about 30 percent more ($p = 0.02$). Thus, although fewer female personnel and personnel in-theater during the summer took PB pills, those that did took more than their peers.

PB PILLS AND PESTICIDES

We found that the number of PB pills taken in a month is statistically significant and positively associated with the total number of applications of personal-use pesticides, even after accounting for known differences in pesticide and PB pill usage. The number of PB pills taken in a month has a small, positive correlation with the monthly frequency of application of personal-use liquids ($r = 0.16$ with $p = 0.06$) and lotions ($r = 0.15$ with $p = 0.04$) individually. Correlations for other personal-use pesticides were insignificant, although with the exception of sprays, this may have been due to insufficient power from too few observations.[11]

To put this in more concrete terms, we estimated the fraction of the population who exceeded certain frequencies of use for PB pills and personal pesticides together. We derived these frequencies from the percentiles of the survey data. As Table 5.4 shows, we estimate that approximately 3,000 personnel took 56 or more PB pills in a month and at the same time applied personal-use pesticides 132 times or more. This averages out to two PB pills per day and four applications of personal-use pesticides. Similarly, we estimate that about 17,000 personnel averaged about one PB pill per day and almost three applications of personal-use pesticides.

Table 5.4
Estimated Number in the Population Exceeding the Frequency per Month Both for Taking PB Pills and for Using Personal Pesticides

	Percentile							
	80th		85th		90th		95th	
	PB	Pesticide	PB	Pesticide	PB	Pesticide	PB	Pesticide
Times/mo	15	60	28	84	31	95	56	132
Estimated no. in population exceeding both	30,549		17,331		9,391		3,100	

None of the field-use pesticides had significant monthly frequency of use correlations with monthly PB pill use and the directionality (signs) were mixed. Pellets and "other sprays" were negative, and the rest had positive (insignificant) correlation. However, field-use liquids had the largest correlation ($r = 0.31$, $p = 0.11$) and was consistent with personal-use liquids.

Frequency of use of personal sprays and lotions was found to be statistically significant in a multivariate regression of the number of PB pills, even after controlling for the effects of other important demographic covariates. We found that individuals who take more PB pills tend to have a greater frequency of use of personal pesticides, particularly sprays and lotions. This relationship may be a result of location, in which personnel in areas subject to pests were also more likely to be concerned about soman attacks.[12]

Figure 5.1 demonstrates the association between frequency of use of personal pesticides and PB pills. The bar shows the percentage of the population who used personal pesticides with a certain frequency. So, for example, about 6 percent of the population applied personal pesticides 120 times or more in a month.[13] To the right is the average frequency of use of PB pills for personnel within each group. For example, the 6 percent who used personal-use pesticides more than 120 times a month took an average of 19 PB pills in a month. Although the association is relatively modest, the effect of even modest combinations of pesticides and PB pills is not fully understood.

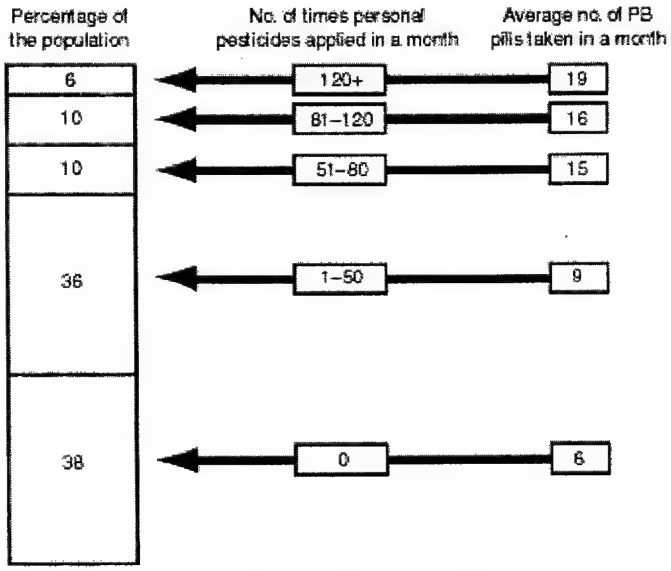

Figure 5.1--Comparison of Frequency of Use of Personal Pesticides to Average PB Pill Use

CONCLUSIONS

Evaluating misuse, multiple use, and overuse with these data is difficult at best because, even when the respondent can name a pesticide, conclusions are still inextricably confounded with recall bias and accuracy issues. For example, the cases we found of possible misuse and overuse can be explained either as true cases of misuse and overuse if one is willing to takes the responses literally. However, the examples of possible misuse of field pesticides are as likely or more likely to be examples of incorrect identification or reporting than misuse. The one clear example of misuse is with flea or tick collars, where there is little question that the respondents correctly identified and reported the pesticide product.

Similarly, it is difficult to find conclusive evidence of overuse of multiple pesticides. First, we can generally identify pesticide products only by form and not by active ingredient. Calculating frequency of use by form is a poor measure in which various active ingredients are unavoidably combined in unknown ways. Thus, we cannot define an objective measure of "overuse" linked to a specific active ingredient. Second, even when we use a basic empirical approach, such as distribution percentiles, it is not necessarily true that people exceeding the 95th percentile actually overused a pesticide. It is only true that they used the pesticide form more frequently in relation to their peers. Third, the data show a correlation between high use of personal and field pesticides, which may be indicative of a seasonal effect, a reporting bias, or some combination of these two and other unknown factors. This makes it difficult to definitively identify those who may have actually used multiple pesticides often and those who simply tended to report higher frequencies of use than their peers.

However, we do find a positive association between the frequency of use of personal sprays and lotions and PB pills. Although the association is relatively modest (roughly, an additional daily application of a spray or lotion is associated with taking two additional PB pills in the 30-day period), the effect of even modest combinations of pesticides and PB pills is not fully understood. If pesticides and PB pills interact over time, as Golomb (1999) suggests, then this result suggests that further study is warranted.

Gambel et al. (1998), in surveys of deployed Army soldiers, found that information about personal protective measures (PPMs) used to prevent arthropod-

related diseases and nuisance bites is not incorporated into commonly used soldier manuals or references and is not routinely trained or tested. They further found that 25 percent of soldiers felt that their commanders did not emphasize the use of insect repellents at all and another 26 percent felt that they emphasized it "some but not enough." Given that limited formal training is provided to Army, Air Force, Marine Corps, and Navy personnel in the use of PPMs,[14] it should not be surprising that individuals varied in their application of PPMs--some failed to use and some tended to overapply in the absence of proper guidance.

The difficulty in teasing these effects out of the survey data should not be taken as evidence that they do not exist, however. In this chapter we have highlighted examples of questionable pesticide use. It seems reasonable to expect that individuals who used one pesticide with a high frequency would also be predisposed to use others similarly. It also seems reasonable that people in environments with large numbers of pests, such as in the Persian Gulf, would be tempted to use whatever means was available to remove the pests, including using products in ways that were not recommended. Indeed, the use of flea collars is a clear example of this. Although we do not find clear evidence of

widespread misuse of other pesticides--the timing and nature of this survey make finding such results difficult--it still may have occurred. We may have simply been unable to detect it almost a decade after the fact.

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[1]Permethrin Arthropod Repellent NSN 6840-01-278-1336 label on each six-ounce can. Approved label by U.S. EPA April 1990. Also in AFPMB (1996).

[2]Gambel et al. found that more than 90 percent of Army soldiers did not treat their uniforms with permethrin before deployment, and more than 75 percent did not treat them during deployment.

[3]Insecticide, aerosol, d-phenothrin, 2 percent NSN 6840-01-412-4634 label on each 12-ounce can. Approved label by U.S. EPA 1982. Also in AFPMB (1996).

[4]Insecticide lindane powder 1 percent NSN 6840-00-242-4217 label on each two-ounce can. Approved label by U.S. EPA 1986.

[5]EXTOXNET *Pesticide Information Profiles (PIPs)* at http://ace.orst.edu/cgi-bin/mfs/01/pips/

methylpa.htm?8#mfs.

[6]AFPMB (1996).

[7]Insect Guard, a product with the identical active ingredient as No-Pest strips and from the same manufacturer, Loveland Industries, is currently being sold in neighborhood drugstores. Although these may have been hung in densities greater than recommended, they may also have been hung in the open air, which would mitigate or eliminate any excessively high pesticide concentrations.

[8]If one of five personnel are African-American (roughly the fraction of the 2,005 respondents), then the chance that out of 13 randomly chosen personnel ten or more are African-American is about one in a million. In this same vein, the senior enlisted results are less striking, although still statistically significant. Roughly 30 percent of respondents are senior enlisted; the chance that seven or more are senior enlisted out of 13 randomly chosen personnel is about one in 50.

[9]See Appendix C for a discussion of the methodology.

[10]PB pills were most commonly taken during late January and February as a defense against a chemical warfare attack. Respondents, however, indicated taking PB pills as early as August 1990 and as late as July 1991. There are two explanations for this: (1) recall bias, with respondents mis-remembering details about the month they were supposed to be recalling, and (2) the possibility that some personnel took pills outside of the specific Gulf War period. We cannot tell whether one or both of these possibilities are true from the survey data.

[11]Sprays and flea collars had insignificant positive correlations; powders and "other" had negative correlations.

[12]Since the association between the regular use of field pesticides and PB pills was not statistically significant, we are inclined to discount recall bias as an explanation for the observed association.

[13]DEET was the most commonly used personal pesticide (technically, it is a repellent, not a pesticide). DEET has minimal AChE inhibitory potency. However, since the data are not detailed enough to allow us to determine exactly what each individual used, we can only aggregate all personal pesticide use.

[14]For example, neither the *CB Combat Handbook Training Manual* (1989), the *Marine Battle Skills Training-Essential Subject Handbook* (1989), nor the *U.S. Army Soldier's Manual of Common Tasks: Skill Level 1* (1990) discusses personal protective measures. The U.S. Air Force has subsequently published *Manual 10/100, Airman's Manual* (1999), which does contain some information about PPMs.

Appendix A: Dose and Exposure Characterizations

SYSTEMIC, ORAL, INTRAVENOUS, AND INTRAPERITONEAL EXPOSURES

Systemic, oral, intravenous, and intraperitoneal exposures are commonly expressed in terms of the weight of the agent (milligrams or micrograms) per kilogram of the weight of the organism dosed.

CUTANEOUS EXPOSURES

Cutaneous exposures may be expressed in terms of a total dose or in terms of the weight of the agent (milligrams or micrograms) per square centimeter times the total area exposed.

The lethal dose (LD) for the organism in question is expressed in one of two ways:

- **LD_{50}** represents the dose that produces 50-percent mortality in the exposed population of interest.
- **LD_{10}** represents the dose that produces 10-percent mortality in exposed population of interest.

The incapacitating dose (ID) for the organism in question is similarly expressed:

- **ID_{50}** is the dose that incapacitates 50 percent of the population of interest.
- **ID_{10}** is the dose that incapacitates 10 percent of the population of interest.

Incapacitation can vary from moderate (unable to see, breathless) to severe (convulsions).

RESPIRATORY EXPOSURES

Respiratory exposures are expressed in terms of the product of the concentration (C) of the vapor or aerosol, usually expressed as milligrams (or micrograms) per cubic meter (or liter), e.g., 35 mg-min/m3 or 0.13 µg-min/l, and the length of the exposure (T). The resulting value is known as the CT.

Note that CT is an expression of exposure, not the amount inhaled or deposited. The same CT can be produced by varying concentration or exposure time. The effect of a given CT may or may not be the same if T is varied from a few minutes to several hours. For example, a CT of 5 can be obtained by exposure to 0.05 mg/m^3 for 100 minutes or to 5 mg/m^3 for 1 minute. The generalization is not reliable for very short exposures (during which breath might be held) or very long exposures (during which metabolic detoxification may operate).

As above, certain key dosages are of interest[1]:

- **LCT_{50}** is the CT required to produce 50-percent mortality in the exposed population.
- **ICT_{50}** is the CT required to incapacitate 50 percent of the exposed population.

[1]These definitions are also used for vapor or aerosol effects on the skin.

Appendix B: Definition of the Sampling Frame and Sample

The sample was drawn from records of Army, Air Force, Marine Corps, and Navy personnel who were reported to have served in ODS/DS between August 1, 1990, and July 31, 1991. These records were subset to those personnel who served on the ground (as opposed to those located at sea in the Persian Gulf or who only flew over the area) in the Kuwaiti theater of operations (KTO). The survey sample was designed to meet the concurrent objectives of providing (1) an overall estimate of pesticide exposure across all services, (2) individual estimates by service, and (3) estimates for various situations or "pesticide scenarios." It achieved this by drawing a diverse sample from across all the services and by oversampling various subgroups. In all, 3,264 records were sampled from 536,790 eligible records, evenly divided across the Army, the Air Force, and the Marine Corps combined with the Navy. Allowing for failure to locate some respondents, nonresponse by others, and errors in the original data (such as misclassifying some personnel as present in theater when they were not), the initial sample of 3,264 records was expected to yield 2,000 complete responses. The survey actually obtained 2,005 complete responses.

THE SAMPLING FRAME

The sampling frame was designed to be an enumeration of military personnel located on the ground in-theater between August 1, 1990, and July 31, 1991. Information from the Personnel and Monthly databases, acquired in October 1998 from USASCURR, augmented with unit location indicators derived from the Locations database by OSAGWI, was assembled to create the sampling frame. It consists of all Army and Marine Corps personnel located in Saudi Arabia, Kuwait, and Bahrain; all Air Force personnel located in Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, and Oman (hereafter referred to as "in theater"); Navy personnel in units that could be identified as being ashore in theater; and all Coast Guard personnel. Thus, the sampling frame consists of the U.S. Armed Services Center for Unit Records Research (USASCURR) Personnel database, merged with the Monthly database and derived location indicators, less the following records:

- All Marine Corps personnel having UICs with latitude and longitude coordinates consistently located at sea in the Persian Gulf and thus assumed to have been permanently stationed on a ship;
- All Air Force personnel with location codes outside Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, and Oman; and
- All Navy personnel at sea.

The sampling frame included as many records as possible; that is, it defaulted in favor of including records rather than excluding them. For example, a sampling frame based solely on personnel location would by design exclude many records with missing data and thus would possibly introduce unknown biases. Note that the Air Force locations included in the sampling frame encompass the United Arab Emirates and Oman, as well as Saudi Arabia, Kuwait, Qatar, and Bahrain, all of which were designated as part of the KTO and geographically adjoin Saudi Arabia. They were included because the Air Force based a significant population in these two countries (approximately 10,000 personnel or roughly 13 percent of the force) under conditions that were likely to have been similar to conditions on bases in Saudi Arabia.

This left 536,790 records in the sampling frame, as shown in Table B.1, from which a stratified random sample of personnel was drawn.

Table B.1
Number of Personnel in the Sampling Frame by Service

Army	349,622
Air Force	78,659
Marine Corps	95,441
Navy	12,220
Coast Guard	848
Total	536,790

The Data Files Used to Construct the Sampling Frame

The U.S. Armed Services Center for Unit Records Research (USASCURR), located at Ft. Belvoir, Virginia, created and maintains the Department of Defense (DoD) Persian Gulf Registry of Personnel and Unit Movement databases in response to the National Defense Authorization Act for Fiscal Years 1992 and 1993, Public Law 102-190 (DoD to Establish Persian Gulf Registry, Section 734) and Public Law 102-585 (Persian Gulf War Veterans' Health Status, Section 704, Expansion of Coverage of Persian Gulf Registry). USASCURR maintains or has archived the following databases:

- The Personnel Registry ("Personnel") database contains information on more than 757,000 Army, Navy, Marine Corps, Air Force, and Coast Guard personnel who served in the Gulf between August 1, 1990, and December 31, 1991. This database was an extension of the Desert Shield/Desert Storm database originally compiled by the DMDC.

- The DMDC unit identification code ("Monthly") database contains periodic UIC data for most of the personnel in the Personnel database. In particular, it contains UIC information for February 1991, the month the ground war started. This database was originally acquired from DMDC.

- The unit movement ("Locations") database contains approximately 800,000 locations for units from all services that deployed to the KTO during ODS/DS. Gulf War unit locations were derived from a labor-intensive review of a wide variety and large number of ODS/DS unit records and through personal interviews with Gulf War Operations Officers (G3/S3) and Commanders. This review began in mid-1994 and the database was continuously updated as locations were obtained. USASCURR gathers unit location information from multiple sources including unit history data archives, operational logs, situation reports, after-action reports, and historical files. Though not complete, it was the most accurate record of unit locations for the war.

Data File Uses and Limitations

The Personnel and Monthly databases provide detailed information about individuals, including demographic, professional, and unit assignment information. When merged, a combined record

includes the UICs to which an individual was assigned over the year of interest. As might be expected, the Personnel database was imperfect. For example, OSAGWI has related anecdotes of listed personnel who did not participate in ODS/DS and, conversely, personnel who were in ODS/DS who were not listed in the database. Unfortunately, there was no measure of either type of inaccuracy. The inclusion of personnel who were not in ODS/DS was accounted for by drawing an initial sample of sufficient size to allow for respondents not meeting the survey entry requirements.

The Locations database links UICs to unit locations, which provides a way to infer the geographic location of personnel. Latitude and longitude coordinates from the Locations database were entered into geographic information system (GIS) software from which it was possible to select the UICs for units in particular geographic locations at specific times.[1] From this, for those personnel with matching UICs for the same time period, indicator variables were attached to the Personnel database to identify subpopulations of interest. In particular, as is discussed below, personnel with UICs that correspond to units located in urban areas on the day before the ground war started--February 23, 1991 (Julian date[2] 91054)--were identified.

There were some difficulties with this approach. First, approximately 100,000 non-Navy personnel records have UICs that were not in the Locations database; these personnel could not be placed in a specific geographic location. Second, the UIC data in the Personnel database was not completely accurate. OSAGWI personnel related that they had found that some UICs did not reflect the unit that personnel actually served with during ODS/DS. For example, the Air Force tended to assign personnel via temporary duty assignment (TDY) and the Personnel database records reflect either their originating unit or provisional unit, not necessarily their unit (or location) in the Gulf. Third, the location of a unit was only an indication of where the individual was likely to have been; even personnel correctly assigned to a unit may have had duties that placed them away from the unit's recorded location. Further, the Locations database itself has inaccuracies: It did not have data for all units, and for many units it did not have locations for all time periods of interest. Finally, almost 6,000 personnel records do not have any UICs. Because of these factors and more, it was not possible to design a sampling strategy strictly around personnel location. However, as is discussed below, location was used to select subpopulations that should have a high percentage of respondents in a particular type of location.

Details of Merging the Data Files

The sampling frame was constructed first by merging the Personnel database and the Monthly database by service and then by selecting the members of the sampling frame.

The Monthly Database. The Monthly database, as received from USASCURR, consisted of 696,643 records, of which 113 were duplicate records by name and social security number (SSN). The duplicate records were eliminated by retaining the records that contained the largest number of UICs. This resolved to keeping 75 Army Guard records instead of Army Reserve records; keeping 25 Air Force Active records instead of Air Force Reserve records; keeping the record with the largest number of UICs for 11 other personnel who had duplicate records between various services and service components; and keeping the Army Guard records over Army Reserve for two personnel who had the same number of UICs in both records. Flags were added to these records so that if one of the 113 was chosen for the survey sample the alternative record could also be retrieved for interviewing purposes. Resolution of the duplicates resulted in a final database of 696,530 records.

The Personnel Database. The Personnel database was received in four sections from USASCURR ,

one for the Navy, one for the Marine Corps, one for the Army, and one for the Air Force and Coast Guard combined. These database sections were individually checked for duplicate records, merged with the Monthly database, subset to remove personnel not in the sampling frame, and then assembled into the final sampling frame of 536,790 personnel. For each service, this process is described separately and in detail below.

Army. The Army Personnel database was received in two sections, one for the Active forces and one for the Guard and Reserves. These were combined to total 357,879 records, of which 69 had duplicate names and SSNs (i.e., 69 personnel had two records each in the combined database). Removal of the duplicates resulted in 357,810 personnel records. These were then merged by SSN with the Army Monthly database of 351,297 records resulting in a combined database in which 79 records did not have UIC data and 38 records did not have personnel data. The majority of the duplicate Personnel records (65) corresponded to the duplicates identified in the Monthly database, and most of them (66) were between the Guard and the Reserves. In both the Monthly and Personnel databases the Guard records were in general much more complete and were kept; thus the choice of kept records in both databases was very consistent. The combined database was then further subset so that the sampling frame included only personnel with in and out dates (the dates they arrived in and then left the Persian Gulf region) overlapping with the survey period (August 1, 1990, to July 31, 1991). Personnel with missing in or out dates, which made it impossible to tell where they were during the survey period, were kept in the sampling frame. This resulted in a final set of 349,622 Army records.

Marine Corps. The Marine Corps Personnel database totaled 103,711 records, of which one person had duplicate entries. The duplication was resolved by choosing the record that matched the Monthly database by component, resulting in 103,710 personnel records. These were merged with the Monthly database for a combined set of 103,710 records, all of which had both personnel and UIC data. (The equivalent terminology in the Marine Corps for UIC is RUC, for Reporting Unit Code.) The data were then further subset so that the sampling frame included only personnel with in and out dates overlapping the survey period and who were not at sea in the Persian Gulf for the entire time. As with the Army, personnel with missing in or out dates, which made it impossible to tell where they were during the survey period, were kept in the sampling frame. This resulted in a final set of 95,441 Marine Corps records for the sampling frame.

Marine Corps personnel were identified as being at sea as follows. First, the Office of the Special Assistant for Gulf War Illness (OSAGWI) and the Center for Health Promotion and Preventive Medicine (CHPPM) identified Marine Corps RUCs in the USASCURR Locations database with latitude and longitude coordinates that put them in the Persian Gulf during the entire time the units were in the Gulf region. Table B.2 lists the RUCs that were classified as Marine units at sea. Second, a Marine was classified at sea if all of their RUCs in the Monthly database between his in and out dates were contained in the list of at-sea RUCs. (Personnel with missing RUCs between their in and out dates were presumed to be ashore.)

Table B.2
Marine Corps RUCs Identified as Being at Sea

RUC	Unit Name
00044	MAG-40
00207	DET, MACG-28
00274	MWSS-274
00820	DET, MASS-1
00971	DET, MACG-38
00973	MACS-6
01296	MATCS-28
01331	VMA-331
12101	2D MARINES RLT
12110	1ST BN 2ND MAR
12110AC	C CO 1ST BN 2D MAR
12130	3D BN 2D MARINES
12130AW	WPNS CO 3D BN 2D MAR
20034	CMD ELE 4TH MEB
20034HS	HQ SVC CO 4TH MEB
20036HQ	HQ CO, 4TH MEB
20460	2D LAI BN
20460HQ	DET HQ SVC CO 2D LAI BN
21610	1ST ANGLICO 1ST SRI GROUP
21610DA	DET, 1ST ANGLICO, 13TH MEU
28390	MSSG-11, 11TH MEU
28390DM	DET, MEDICAL MSSG-11
28391DT	DET, 7TH MT BN

Air Force. The Air Force Personnel database had a total 99,444 records, for which nine people had duplicate names and SSNs. These records were merged with the Monthly database of 82,676 records resulting in a combined set of 83,639 unique records, of which 973 records had personnel data but no UIC data and one person had UIC data but no personnel data. The data were then further subset so that the sampling frame included only personnel with location codes in the area of interest *and* whose in and out dates overlapped the survey period (or the in or out dates made it impossible to tell where they were during the survey period). Table B.3 provides the location codes for the areas included in the survey; personnel missing location codes were included by default. This resulted in a final set of 78,659 Air Force records.

Table B.3
Air Force Location Codes Defined to Be in the Survey Area

Location Code	Location Name	Location Code	Location Name
AAVN	Abu Dhabi, UAE	MFFS	King Fahd IAP, SA
AAVS	Bateen, UAE	MMDL	Kuwait City, KU
ABFL	Ad Dammam PRT, SA	MMDN	Kuwait IAP, KU
ADKL	AL Kharj, SA	NZYR	Manama City, BA
ADKN	Buraymi West APT/Al Ain, UAE	PKVV	Masirah, Oman
ADL3	Al Dhafra, UAE	QEPQ	Thumrait, Oman
ADL5	Al Kharj APT, SA	QJGD	Minhad AB, UAE
ALBQ	Al Jouf OLD, SA	UGYJ	Riyadh New APT/KKIA, SA
ARMY	Use ÒARMY UICÓ For Locations	UGZX	Riyadh IAP, SA
ATXC	Bahrain City, BA	UGZY	Riyadh, SA
ATXK	Bahrain IAP, BA	UYNR	Sirsenk AB, Iraq
FFTJ	Dhahran IAP, SA	VGHV	Seeb IAP, Oman
FHLZ	Doha Intl, QA	VKWD	Shaikh ISA IAP, BA
FMAU	Dubai IAP, UAE	VLJD	Sharjah IAP, BA
KJAZ	KKMC, SA	WPPX	Tabuk/King Faisal, SA
LTWA	King Abdul Aziz AB, SA	WQLS	Taif, SA
LUTC	Jeddah, SA	XJAZ	Classified/unknown
LWEX	Jubail AFD, SA	XPQF	Classified/unknown
MEBG	Khamis Mushayt, SA	XQFT	Classified/unknown

Navy. The Navy Personnel database had 158,003 records, none of which were duplicates. When merged with the Monthly database of 158,000 records, three records were found for which no UIC data existed. Of these, only those personnel likely to have been ashore were selected for the sampling frame. This resulted in a final Navy population of 12,220 persons.

Ashore Navy personnel were identified by UIC as follows. First, UICs were identified as either being ashore or having a function that likely put the unit ashore by either:

- Identifying units in the USASCURR Locations database with latitude and longitude coordinates that put them ashore during the period of interest and which also were not obviously at-sea units (such as ships); or

- Identifying units by UIC name that had obvious ashore functions, such as Navy UICs attached to the Marine Corps, Navy construction battalions, and Seal units.

These units were then checked against the Monthly database to determine how many personnel were attached to those units during their time in the Gulf region, and units with abnormally low or zero personnel counts were removed.

A list of the Navy UICs that were classified as ashore units appears at the end of this appendix (Table B.8). Once the UICs were identified, Navy personnel were classified as ashore if one or more of the UICs that fell between their in and out dates were contained in the list of ashore UICs *and* either their

service time in the Gulf overlapped with the survey period or missing in or out dates made it impossible to tell where they were during the survey period.

Coast Guard. Information on Coast Guard personnel was not available, so all Coast Guard records were included in the sampling frame.

Assembling the Sampling Frame. The sampling frame was assembled by merging the four services into one file. An indicator was attached to the records for 16,525 personnel (by SSN) who were identified by OSAGWI as potentially having lived or worked in an urban area. These personnel were identified in much the same way that the Marine at-sea population was created: First, OSAGWI and CHPPM identified units in the USASCURR database with latitude and longitude coordinates that put them in proximity (most within a five kilometer radius) of a primary city (as listed in the Living Conditions (by Geographic Location subsection) in the Kuwaiti Theater of Operations on February 23, 1991, the day before the start of the ground war. Then, personnel were classified as possibly having lived or worked in a built-up area if one or more of the UICs that fell between their in and out dates were contained in the list of built-up area UICs.

Stratification Variables

The sample was chosen so that pesticide exposure estimates could be generalized to the whole in-theater ashore population of Army, Marine Corps, Air Force, and Navy personnel. Stratification was used to ensure that sufficient data were gathered on particular subpopulations to achieve a given precision in the exposure estimates. Thus, strata determination was largely an effort to define the important population characteristics that were underrepresented, using a simple random sampling scheme, and then specifying the precision desired for the estimates associated with each strata. Conversely, the decision not to stratify meant that sufficient data were gathered via random sampling of the rest of the population to analyze in the nonstratified dimensions.

Subpopulations of personnel useful for stratification were divided into two major categories: exposure-based and knowledge-based. In the former category, the population may be divided into groups that may have been exposed to different levels or types of pesticides; in the latter, personnel may be divided into groups that might have special knowledge of the use of pesticides. Exposure-based variables were principally related to branch (and component) of service, living conditions (primarily by branch of service and geographic location), geographic conditions, time of year, length of time in country, and some occupational specialties. Knowledge-based variables were primarily a function of occupational specialty and perhaps rank.

Each possible stratification variable is discussed in detail below, with a justification for why stratification was or was not necessary. In summary, the sample was drawn stratified by branch of service, food service military occupational specialty, senior enlisted personnel ranks (E-6 through E-9), and living conditions in "urban areas." As mentioned above, the decision not to stratify meant that sufficient data were available to analyze those dimensions without oversampling.

Branch and Component of Service. All services were sampled: Army, Air Force, Marine Corps, Navy, and Coast Guard. As was shown in Table B.1, there were approximately 350,000, 79,000, and 95,000 Army, Air Force, and Marine Corps personnel on the ground in theater on 91054, respectively, which constituted 65 percent, 15 percent, and 18 percent of the personnel. Navy ashore constituted only a small part (roughly 2 percent) of the population and Coast Guard only 0.1 percent. For purposes of sampling, the Navy ashore and Coast Guard personnel were grouped with the Marine

Corps. The Air Force and the Marine Corps/Navy were proportionally oversampled so that exposure estimates for the Army, the Air Force, and the Marine Corps had approximately the same precision.

Reservists and Guard members constituted approximately 24 percent of the Army, 14 percent of the Air Force, and 12 percent of the Marine Corps. However, since Reservists were integrated and operating as members of the Active force, their numbers were included in the total service counts above and service component was not considered as a stratification variable.

Living Conditions by Branch of Service. Since the Army, Air Force, and Marine Corps/Navy/Coast Guard were sampled separately for the reasons discussed above, this stratification requirement was already met. Note that anecdotal evidence indicates that the living conditions for the Army and Marine Corps units were similar, so that sampling the two services separately to analyze their common living conditions may be uninformative. The Air Force, however, used distinctly different tents and was located largely at air bases, which warrants a separate analysis. In any case, stratification by service allows for separate evaluation of service-related living conditions.

Living Conditions by Geographic Location. It was hypothesized that there were four distinct types of living and working locations: (1) urban areas; (2) air bases; (3) permanent, relatively nonmobile "tent cities"; and (4) everything else (i.e., the rest of the troops in the desert). They were characterized as follows:

1. Urban areas: Cities and other urban areas that existed before the war and consisted of permanent structures such as apartment buildings and other converted buildings that U.S. military personnel lived in. The essential descriptors are: (a) urban and (b) existing permanent structures. Examples include personnel who lived or worked in buildings in Al Jubayl, Bahrain, Ad Dammam, Dhahran, Abu Dhabi, Hafar Al Batin, Khobar, and Riyadh.

2. Air bases: Air bases that primarily served the Air Force. They were located in the United Arab Emirates (UAE) and Oman, as well as Saudi Arabia and Bahrain. These air bases may have been similar to the tent cities discussed below, but they also may have had unknown differences, particularly for facilities located outside of Saudi Arabia. Examples include King Fahd (IAP, SA) airfield, Bateen in the UAE, and Seeb IAP in Oman.

3. Relatively permanent, nonmobile "tent city" installations: These were specifically erected by the U.S. military or U.S. and local contractors to house U.S. troops for the war effort. They generally consisted of tents and mobile trailers. These tent cities were distinguished from those erected by front-line troops in that they were relatively stationary for the entire war and tended to be built up and improved upon over the course of their occupation. The essential descriptors here are: (a) not previously existing and (b) relatively permanently located for the duration of the war (i.e., they were not intended to move, as would a front-line encampment). Examples include the logistics bases.

4. Everything else: These were intended to consist primarily of field accommodations for the troops in the desert. Although some may have looked similar to some of the tent cities, they would have been less permanent and may have been moved more often. In all likelihood, they were less densely populated than the tent cities.

Preliminary analysis (based on examination of Army personnel) showed that approximately 40 percent of in-theater personnel lived in relatively permanent, nonmoving tent cities (category 3,

above). For this reason, this category did not require oversampling. Similarly, most of the remaining personnel lived in field accommodations, category 4, and so this category also did not require oversampling. And, the majority of Air Force personnel lived or worked at air bases, so category 2 was evaluated as part of the stratification on Air Force as a service.

Of the four categories, only the number of personnel who lived/worked in buildings in urban areas was small enough to require oversampling. This was achieved by identifying units in the Locations database that were near urban areas and local cities on 91054, the day before the ground war started. The theory behind this approach was that on the day before the start of the ground war, units were highly likely to be in their functional locations. Thus, a unit located in the middle of a city on 91054 was assumed to have a long-term function there, so that the personnel assigned to that unit should be more likely to have either lived or worked in buildings in the city. Of course, proximity of a unit to an urban area does not guarantee that the unit's personnel lived or worked in buildings, but it was hoped that oversampling this population would provide a sufficiently large cohort of personnel who did.

The following areas were identified as urban: Al Jubayl, Bahrain, Ad Dammam, Dhahran, Abu Dhabi, Dubai, Hafar Al Batin, Khobar, and Riyadh. Approximately 26,000 personnel were linked to units located in or near urban areas on 91054. Of this total, approximately 16,100 were Army personnel, 9,700 Air Force, and 400 Marine Corps. Each person was assigned an "urban" indicator, and the Army and Air Force were oversampled to gather a sufficiently large sample living or working in urban areas.

Geographic Conditions. It has been hypothesized that conditions differed between the inland desert and coastal areas, and between the desert and conditions around the Euphrates and Tigris Rivers in Iraq. Preliminary interviews with personnel who served in the War have not uncovered any indication of significant differences between the coastal and inland areas in terms of pests. In addition, troops were exposed to the river areas in Iraq for only a short time. Thus, neither hypothesis was used for stratification.

Length of Time in Theater. Eighty-seven percent of active duty personnel spent more than 60 days in country according to the data; more than 37 percent spent over 180 days in theater. The date data show evidence of rounding to the first of the month or the 31st of the month, but in spite of this, the distribution of length of times in theater was well distributed across the whole range of times. Almost 90 percent of reservists spent more than 60 days in country, but only slightly more than 16 percent spent over 180 days in theater. Thus it was not necessary to stratify on time in theater, as simple random sampling resulted in a robust selection of times with very few times in theater of less than 30 days.

Time of Year. It has been hypothesized that pesticide usage may have varied with the seasons, most notably because of a possible increase in pests during periods of warm weather. Figure B.1 shows the percentage of the sampling frame personnel that were in theater on a particular month. Forty-seven percent of active duty personnel were in theater in October 1990, although half of them arrived that month. The remainder arrived after October, with a peak of almost 17 percent in January 1991, and with much smaller percentages in the other months. Eighty percent of the reservists, on the other hand, arrived between November 1990 and February 1991. Under the assumption that warm weather in theater extends from May through October,[3] over half of the population were in theater either near the end of the 1990 summer or near the beginning of the 1991 summer.

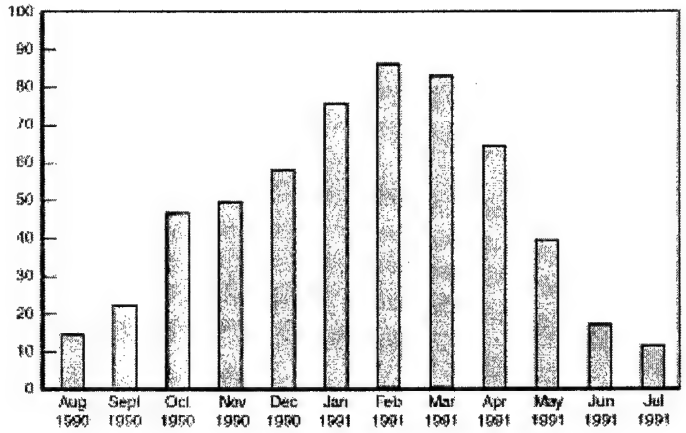

Figure B.1--Percentage of the Sampling Frame Personnel in Theater by Month

Respondents were asked to report their locations in a randomly chosen month that they were in theater. Given that half of active duty respondents were in theater for between two and six months and half (not necessarily the same personnel) arrived in theater during or before October 1990, a random sample asked about a random time was expected to yield a large cohort of respondents who experienced warm weather. Thus, it was unnecessary to stratify on this condition.

Military Occupational Specialties. Food service occupational specialties were hypothesized to have special knowledge of pesticide usage in mess halls (dining facilities). The Army's food service occupational specialties constituted approximately 2.7 percent of the force in theater, the Air Force's approximately 1.7 percent, and the Marine Corps's approximately 1.8 percent. Table B.4 lists the food service occupational specialty codes that were oversampled.

Table B.4
Food Service Military Occupational Specialties to Be Oversampled

Service	Occupational Specialty Code	Description
Army	91M	Hospital food service specialist
Army	94B	Food service specialist
Air Force	623**	Subsistence operations specialist
Marine Corps	3381	Food service specialist
Marine Corps	3311	Baker
Navy	MS**	Mess management specialist

* indicates that any alphanumeric character was allowable in these positions.

Supply occupational specialties were also identified as having special pesticide knowledge. However, survey time constraints did not permit inclusion of additional questions related to supply and food service specialties, so these were not oversampled. Military police was a third occupational category considered for oversampling because of possible exposure to delousing chemicals used with enemy prisoners of war. But delousing procedures were investigated by OSAGWI, so oversampling in this

survey was not conducted.

Rank. It has been suggested that senior enlisted personnel were likely to have a broader knowledge of how pesticides were used and might be able to provide additional useful information. The majority of the personnel in the gulf were junior enlisted: 70.8 percent were E-5 and below, 17.7 percent were E-6 to E-9, and the officer and warrant officer corps constituted the remaining 11.2 percent (with 0.3 percent of the records missing rank information). Senior enlisted personnel, defined as E-6 to E-9, were therefore oversampled.

Summary of the Stratification Variables

In summary, the sample was stratified by branch of service, food service occupational specialty, senior enlisted personnel, and urban areas. Table B.5 tabulates the final sampling frame by service and by the three variables that were oversampled. A "1" in a column means that personnel meeting the description of the column title were included in the "count" total. For example, the last line for the Army shows that out of 349,622 Army personnel in the sampling frame, there were 138 senior enlisted food service personnel attached to units identified in urban areas.

As Table B.5 shows, there were insufficient personnel to completely cross the strata into all 24 possible combinations. (For example, there were no senior enlisted food service Marines in urban areas.) So the oversampling categories were simplified as follows.

- Only Army and Air Force personnel in urban areas were oversampled. (Marine Corps/Navy had very few identifiable personnel in the selected urban areas, and they were restricted to only two Marine Corps units.)
- Food service occupational specialties were oversampled among the non-

  urban population.
- Senior enlisted personnel were oversampled among the nonurban, nonfood service occupational specialty population.

Table B.5
Tabulations of the Sampling Frame by Service and

Categories to Be Oversampled

Service	Food Service	Senior Enlisted	Urban Area	Count	Total
Army	0	0	0	265,557	349,622
	0	0	1	12,404	
	0	1	0	58,733	
	0	1	1	3,240	
	1	0	0	6,828	
	1	0	1	334	
	1	1	0	2,388	
	1	1	1	138	

Marine Corps	0	0	0	82,847	95,441
	0	0	1	291	
	0	1	0	10,646	
	0	1	1	79	
	1	0	0	1,358	
	1	0	1	0	
	1	1	0	220	
	1	1	1	0	
Navy	0	0	0	9,604	12,220
	0	1	0	2,442	
	1	0	0	129	
	1	1	0	45	
Air Force	0	0	0	53,149	78,659
	0	0	1	7,640	
	0	1	0	14,418	
	0	1	1	2,019	
	1	0	0	1,092	
	1	0	1	110	
	1	1	0	203	
	1	1	1	28	
Coast Guard				848	848
Total	1 = 12,873	1 = 94,599	1 = 16,486	536,790	536,790

NOTE: Food service personnel occupational specialty codes were described in Table B.4, and senior enlisted personnel were defined as E-6 to E-9.

This reduced the number of strata to 11, including three "all other" strata for the Army, Air Force, and Marine Corps/Navy/Coast Guard. As the next section will discuss, such a reduction was necessary to achieve an acceptable estimation precision within a reasonable sample size.

DEFINING THE SAMPLE: SIZE AND ADJUSTMENT

The sample size calculations were based on a dichotomous question. The sample was sized so that the width of 95 percent confidence intervals for the percentage of personnel using a pesticide across all services was at most plus or minus 3, and for each individual service, it was at most plus or minus 4. The sample was also divided so that the confidence interval widths by service were approximately equal and the confidence interval widths by strata, particularly the rare strata, were minimized as much as possible within the constraints of the precision of the overall and service estimates.

Equal confidence intervals among the services (Army, Air Force, and Marine Corps/Navy/Coast Guard) were necessary under the assumption that it was desirable to report final results for the services with equal precision. Strata were limited, as described in the last section, to preserve precision in the overall sample estimates.

Assuming that 50 percent of personnel used a pesticide,[4] these requirements dictated a final sample of 2,000 people with 667 respondents for the Army and Air Force, and 666 respondents from the Marine Corps/Navy ashore/Coast Guard. Table B.6 shows how the total sample was divided for oversampling and gives the planned confidence interval widths by service and for the individual strata. The second column ("Number and % in Sampling Frame") provides the fraction of personnel by service in the sampling frame and a breakdown within each service by strata. Comparison of the percentages in this column with those in the third column ("Number and % in Sample") demonstrates the areas and degrees of oversampling; for example, the Air Force made up 14.7 percent of the sampling frame but was oversampled to constitute 33.3 percent of the sample. The fourth column gives the expected width of the confidence intervals by service and strata if simple random sampling (SRS) was employed; the last column shows the confidence interval widths using oversampling based on the sample sizes specified in the third column.[5] The table shows large gains in precision for the smaller strata which comes at the expense of: (a) some of the Army estimates and (b) increasing the aggregate confidence interval width across all the services to 3.2 percent from 2.2 percent under SRS.

Table B.6
The Oversampling Scheme

Stratum	Number (%) in Sampling Frame	Number (%) in Sample	Width of 95% Confidence Interval Under SRS (%)	Width of 95% Confidence Interval with Oversampling (%)
Army	349,622(65.2)	66(33.3)	6	9
Urban area	16,116(4.6)	133 20.0)	26	17
Food service[a]	9,216(2.6)	67(10.0)	34	24
Senior enlisted[b]	58,733 (16.8)	167(25.0)	14	16
All else	265,557(76.0)	300(45.0)	6	12
Air Force	78,659(14.7)	667(33.3)	12	8
Urban area	9,797(12.5)	133(20.0)	33	17
Food service[c]	1,295(1.6)	67(10.0)	90	24
Senior enlisted[d]	14,418(18.3)	167(25.0)	27	16
All else	53,149(67.6)	300(45.0)	14	12
Marine Corps/Navy/Coast Guard	108,509(20.1)	666(33.3)	10	8
Food service	1,752 (1.6)	67(10.0)	78	24
Senior enlisted[e]	13,167(12.2)	167(25.0)	28	16
All else	93,590(86.2)	432(65.0)	11	10
All services	536,790(100)	2,000 100)	4.4	6.4

[a]Personnel with food service occupations among nonurban.

[b]Senior enlisted personnel (E-6 to E-9) among nonurban, non-food service personnel.

[c]Personnel with food service AFSC among nonurban.

[d]Senior enlisted personnel (E-6 to E-9) among nonurban, non-food service AFSC personnel.

[e]Senior enlisted personnel (E-6 to E-9) among non-food service personnel.

Sample Size Corrections

The calculations used to estimate the required sample sizes do not consider the various types of errors that must be accounted for when selecting the initial sample. That is, the initial sample must be inflated to allow for respondent nonresponse, the inability to locate some veterans, and general errors in the database (such as service members who were listed in the database but who were never in ODS/DS or the region of interest).

Nonresponse. An 85 percent response rate was assumed. Decoufle et al. (1991) reported a 92 percent response rate in a similar survey of Vietnam veterans. Of those respondents contacted who were in ODS/DS, the actual nonresponse rate--meaning that the potential respondent refused to participate in the survey--was only 3 percent.

Unlocatability. An 85 percent location rate was assumed. The actual unlocatability rate was 23 percent. Decoufle et al. (1991) reported a 93 percent location rate in their survey of Vietnam veterans, however, that survey used additional locating methods, such as IRS address records, which were not available to us.

Database Errors. A 15 percent overall database error rate was assumed to account for many possible types of errors, including personnel who did not participate in ODS/DS or whose location was misclassified so that they were not in the region of interest; and coding, administrative, and other types of records errors. The actual error rate was 7 percent.

As shown in Table B.7, incorporation of the nonresponse, unlocatability, and database error factors into the original sample size gives adjusted sample sizes of 1,088 for the Army, the Air Force, and Marine Corps/Navy/Coast Guard. This resulted in an initial combined sample of 3,264, which was drawn by strata according to the numbers listed in the last column of Table B.7.

Table B.7
The Initial Sample Size Defined to Achieve 2,000 Complete Final Responses

Stratum	Desired Number in Final Sample	Initial Sample to Be Selected
Army		
Urban area	133	218
Food Service	67	109
Senior enlisted	167	272
All else	300	489
Total Army	667	1,088
Air Force		

Urban area	133	218
Food Service	67	109
Senior enlisted	167	272
All else	300	489
Total Air Force	667	1,088
MarineCorps/Navy/Coast Guard		
Food Service	67	109
Senior enlisted	167	272
All else	432	707
Total Marines/Navy/C.G.	666	1,088
Total	2,000	3,264

Table B.8
Navy Units That Were Classified as Ashore Units

UIC	Unit Name	UIC	Unit Name
N57100	NAV SPEC WARFARE GRU 1	N55103	MOBILE CONST BATT 3
N0031A	NAV SPEC WARFARE GRU 2	N55114	MOBILE CONST BATT 4
N55777	SEAL TEAM 1	N55115	MOBILE CONST BATT 5
N55778	SEAL TEAM 2	N55117	MOBILE CONST BATT 7
N44884	SEAL TEAM 3	N08864	MOBILE CONST BATT 24
N08943	SEAL TEAM 4	N55448	MOBILE CONST BATT 40
N08971	SEAL TEAM 5	N55488	MOBILE CONST BATT 74
N46985	SEAL TEAM 8	N55451	MOBILE CONST BATT 133
N55205	CG I MEF	N55163	CONSTRUCTION BATT UNIT 421
N55207	CG II MEF	N81123	NR CARGO HD BN 3
N55211	CG III MEF	N81124	NR CARGO HD BN 4
N67448	1ST MAR DIV FMF PAC	N82218	NR CARGO HD BN 13
N08321	2ND MAR DIV FMF LANT	N81464	RESERVE CARGO HAND FORCE S
N67360	3RD MAR DIV FMF PAC	N35010	T-AO 107 PASSUMPSIC MILDPT
N67339	CG FIRST MEB	N44291	T-AFS 9 SPICA MILDEPT
N55206	CG FIFTH MEB	N47842	ACADIA REPAIR CO
N55208	CG SIXTH MEB	N68684	FLT HOSP 500 BED CBTZ-4
N55356	CG SEVENTH MEB	N68685	FLT HOSP 500 BED CBTZ-5
N46616	CG FIRST MEB DET NMC HAWAI	N68686	FLT HOSP 500 BED CBTZ-6
N67446	1ST FSSG FMFPAC	N45399	FLT HOSP 500 BED CBTZ-15
N46621	1ST FSSG DET NH CAMP PENDL	N42221	SPECBOATU 12
N68408	2D FSSG FMF LANT	N42223	SPECBOATU 20
N46614	2D FSSG DET NH CAMP LEJEUN	N42224	SPECBOATU 24
N47438	2D MARDIV DET NAVHOSP LEJE	N44394	SPECBOATU 24 SEA DUTY

N46612	2ND MARDIV DET NH BETHESDA	N53210	ASSAULT CRAFT UNIT 2
N67436	3D FSSG FMFPAC	N42056	ASSAULT CRAFT UNIT 2 SHORE
N67683	4TH MARDIV 3RD ANGLICO	N47106	ASSAULT CRAFT UNIT 4 SHORE
N67803	4TH FSSG MEDLOGCO 4TH SUP	N46587	ASSAULT CRAFT UNIT 5 SHORE
N42320	CBAT SVC SUPP DET (CSSD) 1	N67408	1ST RADIO BN FMFPAC
N47114	CBAT SVC SUPP DET (CSSD) 1	N08973	SDVT 1
N41638	CBAT SVC SUPP DET (CSSD) 1	N45597	USCINCCENT SPACT RIYADH SA
N41629	CBAT SVC SUPP DET (CSSD) 2	N79109	USCINCCENT
N53212	BEACHMASTER UNIT 1	N81383	3RD RNCR
N44920	BEACHMASTER UNIT 1 DET A	N45454	ATTACHE OMAN
N44921	BEACHMASTER UNIT 1 DET B	N44349	NAVY IPO DET JEDDAH
N44922	BEACHMASTER UNIT 1 DET C	N79087	NAVY IPO DET JUBAIL
N44923	BEACHMASTER UNIT 1 DET D	N44350	NAVY IPO REP RIYADH
N44924	BEACHMASTER UNIT 1 DET E	N44691	NAVY IPO DET DHAHRAN
N44925	BEACHMASTER UNIT 1 DET F	N46026	NAVSEASYSCOMDET RSNF JUBAY
N41914	BEACHMASTER UNIT 1 SHORE D	N08991	VR 51
N53211	BEACHMASTER UNIT 2	N09014	VR 24
N42055	BEACHMASTER UNIT 2 SHORE C	N09031	HS 75
N66647	CONSTRUCTION BATT UNIT 408	N09043	VP 23
N66649	CONSTRUCTION BATT UNIT 405	N09179	VP 19
N66629	CONSTRUCTION BATT UNIT 407	N09244	VPU 2
N66676	CONSTRUCTION BATT UNIT 411	N09305	VP-91
N66923	CONSTRUCTION BATT UNIT 415	N09362	VP 48
N68571	CONSTRUCTION BATT UNIT 418	N09367	VP 11
N68680	CONSTRUCTION BATT UNIT 419	N09618	VP 1
N55101	MOBILE CONST BATT 1	N09619	VP 49
N09623	VP 4	N09946	VQ 2
N09630	VP 5	N09962	VQ 4
N09632	VP 46	N30197	VC 6 DET DAM NECK
N09661	VP 8	N53855	VR 55
N09665	VP 45	N53869	VPU 1
N09674	VP 40	N53910	VR 57
N09804	VC 5	N53921	VR 59
N09806	VC 6	N53811	HCS 4
N09930	VQ 1	N53812	HELO LIGHT ATTACK SQ 5

[1]The GIS locations used in the sampling plan were derived by the Center for Health Promotion and Preventive Medicine (CHPPM), Edgewood Arsenal, Maryland.

[2]A Julian date consists of five digits; the first two digits indicate the year and the last three digits

indicate the day of the year, sequentially numbered starting at one on January 1st. Thus, 91054 is the 54th day of 1991--February 23, 1991.

[3]"Saudi weather was among the most inhospitable in the world, the temperatures in August and September sometimes reaching 140 degrees Fahrenheit. . . . Between November and March, temperatures moderate considerably" (Scales, p. 121).

[4]Estimated confidence interval width was a function of the percentage, and 50 percent provides the "worst case" scenario; that is, it gives the widest confidence interval. Should the percentage vary from 50, then the smaller confidence intervals will result. Also, note that these calculations do not use a finite population correction, because the sampling fraction was kept to less than 5 percent of the sample frame population, both overall and within each strata (Cochran, 1997, p. 25).

[5]The oversampling confidence intervals were calculated using variances appropriately adjusted using the weights that would result from oversampling. See Cochran (1997, Chapter 5) for calculation details.

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Appendix C: Analytic Methods

SAMPLE (ANALYTIC) WEIGHTS

The survey sample was weighted to account for the differential probability of being sampled among strata, for nonresponse, and for respondent ineligibility. These statistical adjustments allow the analysis to properly infer back to the correct Gulf War population. The calculations were done as follows.

Respondents were randomly sampled within strata. For a predetermined number of respondents to be drawn from strata j, n_j,

$$P(\text{person i in strata j is sampled}) = n_j/N_j,$$

where N_j is the total number of persons in strata j in the sampling frame. In the absence of nonresponse and ineligibility issues, the weight for person i in strata j would simply be $W_i = N_j/n_j$ However, nonresponse and ineligibility affect n_j and N_j, respectively, and they must be adjusted to arrive at weights that will allow proper inference back to the population of interest.

Nonresponse[1] was accounted for using the propensity score method of Little and Rubin (1987) to determine the probability that person i responds given that person i was sampled. This probability was calculated by fitting the logistic regression model

$$P(\text{person i responds} \mid \text{person i was sampled}) = \frac{\exp(i + \text{service}_j + \text{status}_k + \text{rank}_l + \text{race}_m + \text{female})}{1 + \exp(i + \text{service}_j + \text{status}_k + \text{rank}_l + \text{race}_m + \text{female})},$$

where i is the intercept coefficient and the other coefficients are the coefficients for indicator variables corresponding to person i's membership in various groups:

- service_j is the coefficient for service affiliation, j = 1,2,3,4, corresponding to whether the person was in the Army, Air Force, Navy, or Marine Corps;
- status_k is for current status (active duty, reserve, retired, or civilian);
- rank_l is for their rank during ODS/DS, grouped by E-1 to E-5, E-6 to E-9, and officer;
- race_m is the coefficient for race (Caucasian, African American, Hispanic, or other); and
- female is the coefficient if the respondent is female.

These factors were all found to be significant predictors of the probability of response: Individuals who were in the Air Force were more likely to respond than those in the other services; retired personnel were easier to locate than personnel still on active duty or in the reserves, and civilians were harder to locate; and minorities and females were less likely to respond. The model was fit to all persons in the sampling frame less the ineligibles.

From this, the probability that person i in strata j was sampled and responded, $p_r(i)$, was calculated as

$$p_r(i) = P(\text{person } i \text{ is sampled and responds}) = P(\text{person } i \text{ responds} | \text{sampled}) \times P(\text{person } i \text{ in strata } j \text{ sampled}).$$

Similar to the propensity score model for nonresponse, strata sizes were adjusted for ineligibility using a logistic regression model. A model was fit that expressed the probability that a person listed in the Gulf War database was not in ODS/DS based on demographic characteristics. The model was fit to all survey respondents (the eligibles) versus those in the sampling frame who were reached but indicated that they had not served in ODS/DS (the ineligibles). The model is thus similar to the nonresponse model, although the covariates differed to reflect the dimensions important to ineligibility:

$$p_e(i) = P(\text{person } i \text{ is eligible}) = \frac{\exp(i + \text{service}_j + \text{urban} + \text{rank}_1 + \text{race}_m + \text{female} + \text{foodMOS})}{1 + \exp(i + \text{service}_j + \text{urban} + \text{rank}_1 + \text{race}_m + \text{female} + \text{foodMOS})},$$

where, as before, i is the intercept coefficient and the other coefficients are the coefficients for indicator variables corresponding to person i's membership in the previously described groups (less status) plus:

- urban is the coefficient if the respondent was located in an urban area in the Gulf region; and,
- foodMOS, is the coefficient if the respondent were in a food service military occupational specialty.

Both "urban" and "foodMOS" are important predictors of eligibility as those persons were more likely to have been in ODS/DS. In particular, the urban indicator was generated for units known to be in the Gulf War, so personnel whom the database indicated were in these units were more likely to have been in ODS/DS.

To estimate the correct size of the strata, these probabilities were calculated for each of the 536,790 people in the Gulf War database and summed by strata. Thus

$$\tilde{N}_j = E(\#\text{of eligible people in strata } j) = \sum_{i \in j} p_e(i),$$

so that the total number of personnel estimated to have been on the ground in-theater is estimated to be $\sum_j \tilde{N}_j = 469{,}047$. Using the adjusted strata sizes, the final analytic weights for each respondent were calculated as

$$W_{ij} = \tilde{N}_j \left[\frac{p_r(i)}{\sum_{i \in j} p_r(i)} \right].$$

BASIC ANALYTIC METHODOLOGY

In general, we used standard statistical techniques in our analysis. This section describes the

methodology used to account for the stratified random sample and details of the models underlying the results in Tables 4.7 to 4.10.

Standard Error Calculations

In all of the statistical calculations, we used the linearization method (Skinner, Holt, and Smith, 1989) as implemented in the SUDAAN software (Shah, Barnwell, and Bieler, 1997) to account for the stratified sample in our estimates of standard errors.[2] The linearization method uses a first-order expansion to approximate via a weighted sum of random variables a nonlinear statistic. The variance of the nonlinear statistic is then estimated by the variance of the weighted sum, which is estimated using standard formulas for linear statistics. See Skinner, Holt, and Smith (1989) or Shah, Barnwell, and Bieler (1997) for complete details on this method.

Modeling Details

The results of Tables 4.9 and 4.10 are based on log-linear regression models. In particular, for respondents who indicated they used a particular form of pesticide, we modeled the log of the frequency of use as a linear function of various demographic covariates. The model is of the form

$$\log(Y) = \beta_0 + \beta_1 X_1 + \ldots + \beta_n X_n + \epsilon,$$

where Y is the frequency of use, and the Xs are covariates related to population demographics. The fitted model is then of the form

$$\hat{Y} = \exp(\hat{\beta}_0)\exp(\hat{\beta}_1 X_1)\cdots\exp(\hat{\beta}_n X_n),$$

where the Xs are indicator variables representing respondent membership in various demographic categories. Thus, $\exp(\hat{\beta}_0)$ can be interpreted as the average pesticide use for the baseline group, and $\exp(\hat{\beta}_1)$ can be expressed as the percentage change from the baseline rate for a member of the ith demographic group. The baseline group is defined as the group corresponding to having all the indicator Xs in the model set to zero.

Tables 4.7 and 4.8 are based on standard logistic regression models, using the whole respondent population, with a dependent variable that simply indicates whether each respondent said he or she used a particular pesticide form or not. In logistic regression, the log-odds is assumed to be a linear function of various covariates. Thus, the basic form of the model is

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n + \epsilon$$

where p is the probability that a pesticide form was used.

This means that the odds, p/(1 - p), can be expressed as a multiplicative function of the fitted coefficients. Since the covariates in the model are all indicator functions for respondent membership in various demographic categories, the exponentiated coefficients can be expressed as the percentage change in the estimated baseline group's odds, $\exp(\hat{\beta}_0)$.

The logistic regression results for PB pill usage presented in Chapter Five are based on a similar

model--the dependent variable is whether a respondent took PB pills or not--with the same set of covariates.

Standard errors in both the linear and logistic regression models were adjusted for stratified sampling as discussed in the previous subsection.

IMPUTING ACTIVE INGREDIENTS IN PERSONAL-USE PESTICIDES

This section contains information on the process used to impute active ingredients for personal-use pesticides for Tables 3.10 to 3.12. The process was conducted in two main steps: (1) as much as possible, classify active ingredients directly from information given by respondents, and (2) for those that could not be directly classified, impute the probability of active ingredients.

Classification

There are two main classification problems, related to whether the respondent provided a product name or not. In either case, the goal is to try to determine the active ingredient using the information provided. When names were given, and the name was for a known pesticide, the determination of the active ingredient was straightforward. Respondents could also indicate "other" and provide a name not from the survey list. When such an "other" was provided, and when a name could not be remembered at all, the respondent was also prompted for the color, smell, and use of the pesticide. This information was then used to try to identify the active ingredient. Finally, if the pesticide was identified as military issue, but it could not be classified by name or by color/smell/use, then the form was matched to known military-issue pesticides.

When the active ingredient could not be uniquely determined from the information given, all possibilities were recorded. For example, a spray that smelled like insecticide that was used on the uniform could have had either permethrin or DEET as the active ingredient. In such a case, both possibilities were allowed. Then later, as discussed in the next section, the probabilities of whether the spray was permethrin or DEET were imputed from the distribution of uniquely identified active ingredients.

For unnamed products, it was assumed that the pesticide was *appropriately used* when classifying it. For example, sprays that were used on the body only are assumed to be DEET-based and not permethrin (which should have been used on uniforms).

If a pesticide name from the survey list was given, then the active ingredient was classified according to the "rules" listed in Table C.1.

Table C.1
Rules for Mapping Personal-Use Pesticide Products to Active Ingredients

Product Name	Active Ingredient
DEET, Insect/Arthropod Repellent, Cutter Insect Repellent, Off, 3M Repellent, any Cutter personal products, 3M, Repellent	DEET
Permenone; any combination and/or permutation of the following words: Wasp Freeze, Hornet Killer, Wasp Stopper, Raid	Permethrin

Diazinon Dust, Diazinon 4E; Diazol	Diazinon
6-12	Ethyl hexanediol
DDT	DDT
Parathion	Parathion
Chigg-Away	Sulfur
Skin-So-Soft	none

If an "other" name was provided, that name was first used to try to identify the active ingredient. Rules for this are listed in Table C.2.

Table C.2
Rules for Mapping Personal-Use Pesticide Products to Active Ingredients Given "Other" Names (Not Listed in the Survey)

If the "Other" Response Contained:	Active Ingredient
DEET, Deep Woods, Off, Bug Juice, Bug Dope, Muskol	DEET
Permenal, perminal, permithen, permithium, peramone, permenone	Permethrin
6-12, 6-22	Ethyl hexanediol
Phenitrin, dÕphen	d-Phenothrin
DDT	DDT
Parathion	Parathion
Gig-away	Sulfur
Hawaiian Tropic, Skintastic,[a] Soft Scent, Lubriderm	None

[a]Skintastic, a product with pesticide ingredients, was not available in 1990-1991. We thus assumed that it was a nonpesticide commercial lotion.

For unnamed pesticides and those pesticides that could not be classified according to the "other" name given, the active ingredient was inferred from some combination of form, color, smell, and use. The rules for this classification are given in Table C.3.

Table C.3
Rules for Mapping Unnamed Personal-Use Pesticide Products, by Color, Smell, and Use to Active Ingredients

Form	Color	Smell	Use	Active Ingredient
Spray	n/a	Off, DEET, or sweet	Any	DEET
Spray	n/a	Raid	Any	Permethrin
Spray	n/a	Insecticide or chemical	Body	DEET
Spray	n/a	Insecticide or chemical	Uniform or body and uniform	DEET or permethrin

Powder	White, cloudy, cream, yellow, or gray	Insecticide, chemical, or musty	Any	Lindane
Liquid	Clear	Sweet, off	Any	DEET
Liquid	White, clear, light brown, or yellow	Sulfur	Any	Sulfur
Liquid	White or yellow	Insecticide or chemical	Any	Permethrin
Liquid	Clear	Insecticide or chemical	Body	DEET
Liquid	Clear	Insecticide or chemical	Uniform or body and uniform	DEET or permethrin
Lotion	White, clear, light brown, or yellow	Sulfur	Any	Sulfur
Lotion	White, cloudy, cream, or clear	Insecticide or chemical	Any	DEET
Stick or Wipe	Any	Any	Any	DEET, Ethyl hexanediol

In addition, for respondents reporting multiple smells, the smell response could not contain: alcohol, cooking oil, diesel, gasoline, kerosene, medicine, musky, petrol, or powder. The smells of musty and sulfur *had* to be alone to code to lindane or sulfur, respectively. And perfume alone did not code to any active ingredient.

If the active ingredient could not be classified via the rules in Tables C.2 and C.3, but a physical description of a military-issue container was provided, the rules in Table C.4 were used.

Table C.4
Rules for Mapping Personal-Use Pesticide Products, Where "Other" Response Reflected That the Pesticide Was Military Issue(and It Did Not Otherwise Classify)

If the "Other" Response Indicated The Pesticide Was Military Issue And It Met The Following Conditions:			
Form	Use	Other Conditions	Active Ingredient
Liquid or spray	Body		DEET
Liquid or spray	Uniform or body and uniform		DEET or Permethrin
Liquid	Any	Comments or smell field gave a sulfur smell	Sulfur
Lotion	Any	Comments indicated a "tube" container	DEET
Lotion	Any	Comments indicated a "bottle" or "green" container	DEET
Powder	Any	Comments or smell field gave a musty smell	Lindane

Finally, if only a subset of the information was given, say form and color but not smell, then the response was mapped to all possibilities with matching form and color. If color or smell did not map to those values in the table, it was treated as missing. In the most extreme case, if both smell and color were missing, then the response was mapped to all the active ingredients for that form (consistent with the reported use).

Imputation

Frequently, the classification scheme previously described resulted in multiple active ingredient possibilities. To calculate the personal pesticide usage by active ingredient in Tables 3.10 to 3.12, we imputed the fraction of the population exposed to each active ingredient. The calculations were conducted in three main steps: (1) The probability that a respondent used each active ingredient was estimated, (2) the frequency of use was combined and the fraction of the population for each frequency of use estimated, and (3) the variability of the various usage statistics was calculated.

Probability of Active Ingredient Estimation. To estimate the probability that a respondent used an active ingredient, we used a methodology motivated by the EM algorithm of Dempster, Laird, and Rubin (1977). Since the distribution of pesticides varied by demographic characteristics, personnel were grouped into similar cohorts to condition the calculations on those characteristics. Sprays and liquids were conditioned on service and usage (body, uniform, or body and uniform); all others were conditioned on service and gender.[3]

Let p_d, p_p, p_b, and p_o be the unknown probability that a random individual in the cohort used the active ingredients DEET, permethrin, sulfur, and "other," respectively. For a given respondent in the cohort, let I_d, I_p, I_b, and I_o be indicators derived from the classification scheme for whether the respondent may have used each of the active ingredients.

For each cohort, the distribution of pesticide use was imputed as follows. First, all the uniquely identifiable pesticides were used to generate an initial estimate of the distribution on active ingredients. For a given cohort, this was estimated as

$$\tilde{p}_i^1 = \frac{\sum_j I_i W_j}{\sum_i \sum_j I_i W_j},$$

for all j in the cohort and where i = d, p, b, or o. Then, each individual's probability of using an active ingredient was estimated as

$$\hat{p}_j^1 = \frac{\tilde{p}_j^1}{\sum_i \tilde{p}_i^1}$$

The cohort's overall probabilities and individual probabilities are then iteratively reestimated by alternating between

$$\tilde{p}_i^{k+1} = \frac{\sum_j \hat{p}_i^k W_j}{\sum_j W_j} \text{ and } \hat{p}_j^{k+1} = \frac{\tilde{p}_j^{k+1}}{\sum_i \tilde{p}_i^{k+1}}$$

until

$$\max_i |\tilde{p}_i^{k+1} - \tilde{p}_i^k| < \epsilon$$

.

We ultimately used $\epsilon = 0.01$ after empirically determining that the final result was insensitive to further reductions in ϵ.

Estimation of Frequency of Use. To estimate the frequency of use for each active ingredient by the fraction of the population represented by person i, it was necessary to combine the various frequencies of use between and within forms. For example, person i may have used two sprays and one liquid, each of which had some probability of being DEET and another probability of being permethrin, and each had a reported frequency of usage. Some individuals in W_i, the fraction of ODS/DS population represented by person i, may have used all DEET products, so that their DEET usage is the sum of the three use frequencies and their permethrin usage is zero. Others may have used all permethrin products and no DEET, and still others may have used some combination of active ingredients.

To estimate the fraction of each W_i that used a particular active ingredient with a particular frequency, we assumed that for each person the probability of using one product was independent of the probability of using another product. Each person could have reported using up to nine personal products (three sprays, three liquids, and three lotions) that could have contained the active ingredients of interest (DEET, permethrin, and sulfur). Each product reported had a frequency of use and an imputed probability distribution on the three possible active ingredients and "other nonpesticide."[4] For each person, let f_{ij} be the reported frequency of use for product j, j = 1, . . . 9. Let p_{ijk} be the imputed probability that product j has active ingredient k. Finally, let I_j be an indicator variable for product j and let the group of nine indicators **I** form a column vector. There are $2^{(9-1)} = 511$ possible vectors for which at least one indicator is nonzero. Each vector represents a combination of products that might have contained a particular active ingredient.

Then, for each indicator vector, we calculated

$$F = \sum_{f_{ij}>0} I_j f_{ij}$$

and for each F > 0 we then calculated

$$\text{E(\#using active ingredient k with frequency F)} = W_i \prod_{f_{ij}>0} [I_j p_{ijk} + (1 - I_j)\bar{p}_{ijk}].$$

The result is that each survey respondent's weight, W_i, is apportioned by active ingredient and frequency of use within active ingredient.

Estimation of Standard Errors. To capture the uncertainty resulting from the imputation of active ingredients, we used the Bootstrap (Efron and Tibshirani, 1993) to calculate standard errors. For a given statistic, say the mean frequency of usage of an active ingredient, its standard error is calculated as follows. Let $\bar{Y}$ be the mean frequency of usage calculated. Then the Bootstrap proceeds to resample with replacement from the original observations. Because this was a stratified random sample, the resampling was done with replacement within strata, maintaining the total number of resampled observations within each stratum equal to the original number of respondents in each stratum. After each resample was drawn, the entire imputation was redone, and a new bootstrap statistic, $\bar{Y}_{(k)}$, was calculated, k = 1, . . . ,M. From these bootstrap statistics $s.e.(\bar{Y})$ is estimated as

$$s.e.(\bar{Y}) = \left[\frac{1}{M-1}\sum_{k=1}^{M}(\bar{Y}_{(\cdot)} - \bar{Y}_{(k)})^2\right]^{1/2}$$

where

$$\bar{Y}_{(\cdot)} = \frac{1}{M}\sum_{k=1}^{M}\bar{Y}_{(k)}.$$

We ultimately used M = 200 in the calculations, consistent with what is normally recommended (Efron and Tibshirani, 1993), as our results differed insignificantly for M = 400.

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[1]"Nonresponse" as used in this appendix includes those who refused to participate and those who were not located--essentially everyone in the sampling frame who did not complete the survey, minus those who were ineligible.

[2]Except for the imputation of personal-use active ingredients in Tables 3.10 to 3.12, as described in the next section.

[3]Additional conditioning was not possible of because small cell sizes.

[4]Although the survey asked only about pesticides, respondents sometimes reported nonpesticides. Thus, to avoid bias in the imputation, we also imputed from the nonpesticides and estimated a probability that a product was not a pesticide.

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Appendix D: Evaluating Recall Bias

Despite the survey design elements used to prompt recall, we were concerned about respondents' ability to remember, and remember accurately, events from ODS/DS. There is no way to conclusively evaluate how well our survey population recalled exposure to pesticides without recourse to detailed exposure records, which in our case do not exist. Therefore, we cannot know definitively whether some survey respondents were systematically underreporting exposure or other respondents were overreporting exposure. Both add error to our measure of exposure; in the end they may neutralize each other.

However, we felt compelled to try to evaluate how recall might affect our results. In the absence of such an evaluation of the accuracy of recall, we would have had to assume that respondents' responses reflected exactly what occurred during ODS/DS. However, we know that recall of events almost a decade in the past is likely to be imperfect. This chapter examines the extent of this imperfection by comparing the follow-up (recall bias) survey we administered to the main survey data.

METHODS FOR ASSESSING RECALL BIAS

We reviewed the scientific literature on recall bias and learned that memory can be unreliable in two ways. First, some details of an experience may never be noticed or stored in memory. For example, personnel may not be aware of the pesticides used in their mess halls. Second, information may be added later if memories are "rehearsed," that is, events are recalled by thinking or talking about them and then re-stored in memory. Rehearsal increases the ease with which we can recall memories, and failure to rehearse or recall a memory for a long time can make it difficult or impossible to retrieve it when it is wanted. However, rehearsal can also contaminate the original memory: When the memory of an event is recalled to consciousness, other new "facts" about the event may be added as the event is embellished, made more socially acceptable, redefined to fit present-day conceptions, or appended in any number of additional ways. When the memory is again stored in long-term memory, it may be stored in an altered fashion that includes new information. If the altered memory is the one that is most rehearsed, then it is likely to become the perceived "real" memory.

We were less concerned with this aspect of recall, as pesticide exposure has not been prominent among Gulf War issues. What it does highlight, however, are the two aspects to remembering: ability and effort. We reviewed the extensive literature on questionnaire design, memory, and recall to avoid where possible the methodological pitfalls to which self-reports of exposure may be prone, and we designed the main survey with the findings from this literature in mind. For example, the literature suggests that easily demarcated events--such as a war--are easily recalled, but mundane day-to-day events--such as pesticide use-- may not be. Our goal was to construct a survey that would aid accurate recall by helping respondents reconstruct the context of their experiences. This included questions regarding attributes of respondents' living and working environments, questions on the kinds of pests they faced, and questions designed to help them reconstruct a timeline of their experiences. These questions were intended to encourage their recall of the day-to-day aspects of their life while in the Gulf region.

Assessing Recall Bias Through Re-Survey

To evaluate the effect of recall on our survey results, we administered a second survey to a small

sample of initial survey respondents. To avoid overinterpreting any one question or type of question, we surveyed and examined multiple dimensions along which systematic recall bias may have occurred, such as service, pay grade, education, and reported health status. In short, we employed multiple tests of recall bias in the knowledge that no single measure could accurately capture the extent of recall bias as a whole. Multiple tests avoid overinterpreting any one measure, question, or set of questions. This is also important because there may be offsetting biases, none of which could be predicted in advance of the survey. Some analysts find that recall bias contaminates their results; other analysts conclude that recall bias does not affect respondents' answers. Our purpose in administering the recall bias survey and otherwise assessing the reliability and consistency of respondents' answers is to place an honest range of uncertainty around our estimates of pesticide exposure. This allowed us to assess the level and direction of bias, and to clearly report the sensitivity of our results to it.

We cannot know definitively how well survey respondents recall pesticide exposure. However, the literature suggests that we can gauge the extent to which recall might affect our results by examining how changes in reported use at re-survey vary by certain individual characteristics. These include health status and sensitivity to the issues of pesticide use and Gulf War illnesses, as well as other demographic factors such as education.

Recall Bias and Health Status

We employed a commonly asked question designed to elicit information about the respondent's current health. As discussed above, the ability to recall past events is in part dictated by people's willingness to put the effort into remembering. Currently ill respondents already will have invested time and energy into thinking about their health and may be both more sensitized to public discussions of the issue and more attentive to factors hypothesized to negatively affect health. This can cause them to overreport exposure if in the process of remembering they have assimilated the experiences of others into their own. Conversely, illness may cause underreporting of exposure, if current illness hampers respondents' ability to concentrate, for example. Thus, it is not possible to predict in advance which effect will dominate, but collecting data on current health status helps to determine whether a possible problem with recall bias exists.

To reiterate, we are not able to draw firm conclusions about exposure and recall bias solely using information on health status. If ill respondents report more exposure, for example, this could be interpreted several ways: (1) It could be true; (2) it could be because they have been following the debate and talking to others about their experiences; or (3) it could be that healthy respondents are not interested enough in this issue and therefore do not put the same level of effort into remembering. Our objective in collecting the data is simply to document whether responses vary by current health status, rather than to draw definitive conclusions.

Recall and Sensitivity to Gulf War Issues

Further, the public controversy over Gulf War illnesses could affect how much effort the respondent puts into recalling pesticide use. Respondents uninterested in revisiting issues related to the war may try to rush through the survey; respondents following such issues more closely may take more time to try to remember. We assessed these potential markers of recall bias in several ways. One method we used was to ask early in the survey (before trying to elicit memories of exposure) how much interest the respondents have generally had in Gulf War issues and whether they have thought much about the pesticides they encountered during their tours of duty. Another method was to ask whether

respondents reporting fair or poor current health thought their health status was linked to the Gulf War or whether their doctors thought so. We also asked respondents if they had registered with the Veteran's Administration or Department of Defense registries, since veterans who have registered may report higher or lower levels of pesticide exposure. Although there is no causal conclusion to be drawn from such an association, we wanted to reveal any systematic patterns of differential response within our sample. One important dimension along which they might differ would be the extent to which they are presently engaged in Gulf War issues.

RESULTS

The recall bias survey sample is approximately 8 percent of the full sample, which means that it is large enough to statistically detect changes in answers that most survey respondents gave, but not in some of the less common answers. Thus, our initial analysis focuses on stability in aggregate measures: number of pests and types of pests observed, number of types of personal pesticides used, and number of types of field pesticides used. We also concentrated more on the patterns across subgroups and across outcomes than on statistical significance. We then examined personal-use sprays and animal traps, the most commonly reported personal and field-use pesticides, in more detail. This part of the analysis included how they were used, and whether the same pesticide name was reported in both surveys.

We found evidence of changes in responses overall, with the fraction reporting pesticide types increasing about 13 percent in the re-survey. We did not see strong patterns among the various groups in our data; this includes not only demographic groupings, such as education or rank, but also self-reported health status. However, we also found that people who thought about their pesticide exposure before our survey reported more pesticide use, but their

answers were in fact more stable over time. We interpreted the pattern of differences as an indication that people who had not thought about pests and pesticides since the war were less likely to put as much effort into recalling their experiences for our survey. Answers on how pesticides were used (such as number of sprays used or frequency of use) were stable across surveys. In general, most respondents did not report names of pesticides in either survey, nor did they use most types asked about. This remains the most salient finding across the two surveys.

Analysis of Recall Bias Across Groups

To compare answers across various groups in the data, such as service or rank, we examined responses to questions about aggregate pesticide usage, such as number of types of pesticides used or observed. We also evaluated the number of kinds of pests reported.[1] The results are reported in Table D.1. Overall, the 193 respondents in the follow-up sample reported seeing 5.28 types of pests on average in the original survey; in the follow-up, they reported 0.22 fewer types, or 5.06 types of pests. The 4 percent drop is statistically significant. They also reported using 0.88 types of personal-use pesticides (liquids, sprays, powders, etc.) and reported 0.99 types in the follow-up survey, a statistically significant increase of 13 percent. The number of types of field-use pesticides reported in the follow-up survey also increased by 13 percent and, again, this was statistically significant. As people had more time to consider their answers during the period between surveys, they might have simply convinced themselves that they saw more or experienced more of everything. Instead, the results suggest that recall of *pests* was more reliable than recall of *pesticides*. It appears that respondents considered their experiences more thoroughly in light of our questions and answered more carefully the second time.

Table D.1
Correlates of Recall

	Average Number of Pests	Change in Average Between Surveys	Average Number of Personal-Use Pesticides	Change in Average Between Surveys	Average Number of Field-Use Types	Change in Average Between Surveys
Overall	5.28	-0.22*	0.88	0.11*	1.35	0.18**
Air Force	5.45	-0.04	0.66	0.14*	1.50	0.16
Marine Corps	5.23	-0.14	1.15	0.02	1.38	0.29**
Army	5.45	-0.59**	0.89	0.14	1.20	0.07
Navy	++	++	++	++	++	++
Caucasian	5.15	-0.08	0.83	0.13**	1.30	0.18**
African-American	5.86	-0.76*	1.07	0.03	1.52	0.14
Other	5.38	-0.43	0.95	0.05	1.48	0.24
Male	5.37	-0.21	0.91	0.11**	1.41	0.22**
Female	4.44	-0.33	0.50	0.06	0.83	-0.17
Active	5.33	0.03	0.78	0.23**	1.63	0.20
Reserves	4.76	-0.04	1.00	0.08	1.04	0.32*
Retired	5.09	-0.14	0.70	0.05	1.32	0.09
Civilian	5.51	-0.43**	0.98	0.10	1.33	0.18*
E-1 to E-5	5.52	-0.32*	0.92	0.12**	1.33	0.20**
E-6 to E-9	5.20	-0.15	0.7	0.08	1.45	0.03
Officer	4.11	0.16	1.00	0.11	1.16	0.53*
High school or less	5.08	-0.21	0.85	0.03	1.39	0.21
Some college	5.79	-0.13	0.86	0.18**	1.35	0.15
College graduate	4.61	-0.42	0.95	0.13*	1.29	0.18

NOTE: The sample used for estimation was the follow-up sample (n = 193).
**p-value ≤ 0.05; *p-value ≤ 0.1 from paired t-test of original average to follow-up average.
++Answer suppressed because there are under 10 cases in the cell.

Aware that, given time, respondent' answers could change, we looked for evidence of systematic bias in their answers. We examined multiple dimensions along which we might expect to see such bias, such as service, pay grade, education, and reported health status. Although the total sample size is 193, dividing the sample to look for subgroup differences is statistically difficult, as the power of the tests is reduced due to small numbers. Thus, we did not necessarily expect to find statistically

significant results in this part of the analysis. Instead, we placed more weight on the patterns across subgroups and across outcomes, and there we interpreted the results as lacking evidence of systematic bias among subgroups in the survey sample.

The results of this analysis are shown in Table D.1. Although Army members reported many fewer pest types, they did not exhibit the most change in personal-use pesticides (the Air Force did, percentage-wise) nor of field-use types (the Marine Corps showed the largest percentage change). Similarly, African-American veterans report the largest change in the number of pests, Caucasians the largest change in number of personal-use pesticides, and other races the largest changes in field-use types. More educated respondents remembered relatively more personal-use types in the follow-up survey, whereas less educated respondents remembered relatively more field-use applications. The only group whose answers changed in statistically significant ways for all three variables were junior enlisted personnel (pay grades E-1 to E-5), who remembered fewer pests and more pesticides, both personal and field use. This is somewhat, but not entirely, correlated with age, as younger respondents were more likely to be junior enlisted.

One unusual result we found--likely related to recall bias but not related to the recall survey--was that personnel currently on active duty tended to give names of military pesticides whereas civilians tended to give names of nonmilitary pesticides. That is, named pesticides tended to be related to a respondent's current status. We attribute this differential to recall, with current active duty personnel likely having been more recently aware of military products. In contrast, civilians are less likely to have recently been in contact with military products and more likely to have used or otherwise been in contact with nonmilitary products.

Reported Health and Awareness of the Research Hypothesis

We were interested in how perceived health affects responses. For example, we were concerned that poor health might give respondents an extra incentive to think about their experiences and report pesticide use, or that poor health might inhibit memory. However, we also knew that self-reported health measures may not be reliable indicators of actual health and may be influenced by question wording, in particular, the order in which the responses are presented (Means et al., 1989). Thus, we randomly assigned to half of the original sample a question that asked to them rate their health from excellent to poor; the other half of the sample were asked to rate their health from poor to excellent.

As expected, we found that when excellent was the first response presented, as shown in Table D.2, respondents reported better health on average than when poor was the first response presented: 47 percent replied that their health was excellent or very good when those answers were presented first, compared with 36 percent of the other group. The difference is statistically significant ($p = 0.07$).

Table D.2
Self-Reported Health Status (percent)

Health Status	Version A (n = 86)	Version B (n = 107)	Version C (n = 193)
Poor	5.8	2.8	4.2
Fair	10.5	23.4	17.6
Good	37.2	38.3	37.8
Very good	26.7	25.2	25.9

Excellent	19.8	10.3	14.5

NOTES; Response categories were read aloud to the survey respondent. Version A of the question ordered response categories from excellent to poor; Version B was ordered poor to excellent. The sample used in estimation was the follow-up sample (N=193).

Nonetheless, other survey responses appear to be relatively unaffected by health status and by which version of the question was asked. Respondents in both fair/poor and very good health reported seeing more pests in the initial survey than did respondents in good or excellent health, and those reporting fair/poor health also reported fewer pests in the follow-up survey. We cannot explain this odd pattern, having expected to see a smoother change across categories, and so we interpret this to mean that there is no systematic bias by health status. More important, there were no significant differences by health status or question version for number of personal pesticides used and number of field applications witnessed. This is shown in Table D.3, which reports the coefficients from a regression of number of pests (number of types of use) on the health measures and the version of the question asked.

Table D.3
Coefficients from a Regression of Levels and Changes Between Surveys on Health Measures and Question Wording

Health Status	Average Number of Pests	Change in Average Between Surveys	Average Number of Personal-Use Types	Change in Average Between Surveys	Average Number of Field-Use Types	Change in Average Between Surveys
Poor/fair	1.23**	-0.77*	0.16	-0.08	0.10	-0.03
Good	1.00	-0.34	0.31	0.01	-0.02	0.04
Very good	1.06*	-0.59	0.18	-0.03	-0.05	0.09
Version A	0.20*	-0.12	0.01	0.07	0.03	-0.04
Constant	4.27**	0.29	0.67**	0.10	1.34**	0.17
R-squared	0.03	0.02	0.01	0.01	0.00	0.00

NOTE: The sample used for estimation was the follow-up sample (n = 193).
**p-value ≤ 0.05, *p-value ≤ 0.1.

We also explored how these estimates changed when we included whether someone in poor/fair health had reported being enrolled in a Gulf War Registry. For the most part, the estimates remained similar to those reported above. It was interesting that registrants remembered more pesticides (both personal and field-use), and their answers across surveys were more stable regarding the number of types of personal pesticides they used. This is in keeping with the initial survey's questions about how much respondents had thought about pests and pesticides, with those answering "a lot" reporting more pests and more personal pesticide use; additionally, their answers did not change as much across surveys. As shown in Table D.4, those who reported in the initial survey that they had thought very little ("almost none") about pests and pesticides before the interview (most of the sample--see

the Introduction) also reported fewer pesticides types in the second interview. The survey asked difficult-to-remember questions about events eight years before the interview. We suspect that respondents who had not thought about pests and pesticides in the intervening years did not put as much effort into remembering their experiences the first time through the survey as did the rest of the sample.

Table D.4
Awareness of Gulf War Issues

	Average Number of Pests	Change in Average Between Surveys	Average Number of Personal-Use Types	Change in Average Between Surveys	Average Number of Field-Use Types	Change in Average Between Surveys
Overall	5.28	-0.22*	0.88	0.11**	1.35	0.18**
Before today, how much have you thought bout your Gulf War experiences in general?						
A lot	5.67	0.42*	0.97	0.00	1.30	-0.07
Some or a little	5.21	0.06	0.89	-0.17**	1.36	-0.28**
Almost none	4.27	0.67	0.40	-0.07	1.53	0.13
Before today, how much have you thought about problems you had with pests, rats, or other pests in the Persian Gulf, and the pesticides you used to get rid of these problems?						
A lot	6.00	0.65	1.18	-0.29*	1.53	-0.18
Some or a little	5.78	0.08	1.12	-0.06	1.49	-0.16*
Almost none	4.76	0.25	0.64	-0.11**	1.21	-0.20**

NOTE: The sample used for estimation was the follow-up sample (n = 193).
**p-value ≤ 0.05; *p-value ≤ 0.1 from t-test of original average to follow-up average.

Change Across Surveys in Pesticide Use

In both the original and follow-up surveys, we asked whether a particular spray, lotion, or other personal pesticide was used on the body, on the uniform, or both. These answers did not change much. Spray use was most likely to change, and in a pattern we did not anticipate: 10 percent changed their answer from both to just one type of use. Nonetheless, 86 percent reported the same answer in both surveys.

The results for whether someone named the pesticide in either or both surveys were similar. People who named pesticides in the first survey named fewer pesticides in the second survey. We did not expect that. Yet very few named a spray (the most common personal-use pesticide form) in either survey. Of the 24 who provided a name in the follow-up survey, 96 percent gave the same name. It is easy to lose sight of the fact that 83 percent did not change the number of names they provided across surveys, whether they specified a name or not. In other words, few people remembered pesticides by name and this did not change substantially across the two surveys.

We also asked about the number of personal pesticides respondents used by type and the number of field applications they observed. Personal use appears to be stable when taken as a whole--74 percent reported using exactly the same number of sprays in both surveys, 12 percent reported more sprays, and 12 percent reported fewer sprays.[2] Reported frequency of use also remained stable across surveys. As shown in Table D.5, one interpretation of this result is that field use could be underestimated on average in the main survey. The extent of the difference was statistically significant at the 95 percent significance level or better for traps, pellets, and sprays from trucks. Again we note, however, that most answers did not change, largely because most people reported no field use in either survey.

Table D.5
Percentage Reporting Field Use of Pesticides Across Surveys

	Reported in Original Survey, But Not in Follow-Up	Answer Did Not Change	Did Not Report in Original Survey But Did in Follow-Up	Change in Average Percentage Reporting Use
Animal traps	6.5	80.5	13.0	+12**
Powders	3.9	89.5	6.6	+30
Pellets	0.6	95.5	3.9	+25**
Aerosol	7.0	85.0	8.0	+4
Spray from a truck	1.6	93.6	4.8	+11**
No-Pest strips	3.2	91.4	5.4	+44

NOTE: We examined only forms for which at least 10 people in the follow-up survey reported observing field use.
**p-value $\leq$ 0.05.

CONCLUSION

The frequency of reporting of pesticide types increased in the re-survey by 13 percent. This change occurred primarily among respondents who had given less thought to their Gulf War experiences in the intervening years, but was not systematically related to other individual characteristics. We hesitate to provide a specific interpretation of these results given the complex nature of recall bias and the fact that ultimately we are only measuring differences between the two surveys--differences that could occur for many reasons. However, a "worst case" interpretation of the results is that the incidence of pesticide reporting could be underestimated in the initial survey.

Although the overall frequency of pesticide use may be somewhat higher than the survey results show, there is no evidence that different pesticides were subject to different levels of recall bias. This was qualitatively true even for field use, which showed varying degrees of change according to the type of application reported. There we found somewhat large percentage changes but low overall reporting, and we note that it is easy to lose track of the fact that a large percentage increase in a small number is still a small number. Therefore, we conclude that the mix of pesticides reported in the main

survey does not appear to be misestimated.

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[1]This question was used to prompt memories of pesticide use by encouraging respondents to recall why they needed pesticides. We did not expect respondents' answers to change across surveys, and so we use this as a gauge of the magnitude of the change in the pesticide measures.

[2]Ninety-four percent of those who report using a liquid give identical answers across surveys about the number of liquids. The other forms do not have at least 10 people reporting use, and so we do not analyze the answers.

Contents
Appendix C
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Contents
Appendix D

INTERNET DOCUMENT INFORMATION FORM

A. Report Title: Pesticide Use During the Gulf War: A Survey of Gulf War Veterans

B. Report downloaded From the Internet: JANUARY 17, 2001

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